REINFORCED CONCRETE FLOORS

NATIONAL STEEL FABRIC CO.
PITTSBURGH, PA. U.S.A·

NATIONAL REINFORCING

SIR FABRIC

NATIONAL REINFORCING

TRADE MARK

As used for

REINFORCEMENT

in

CONCRETE FLOOR and ROOF SLABS

National Steel Fabric Co.

DIVISION OF

[Pittsburgh Steel Co.]

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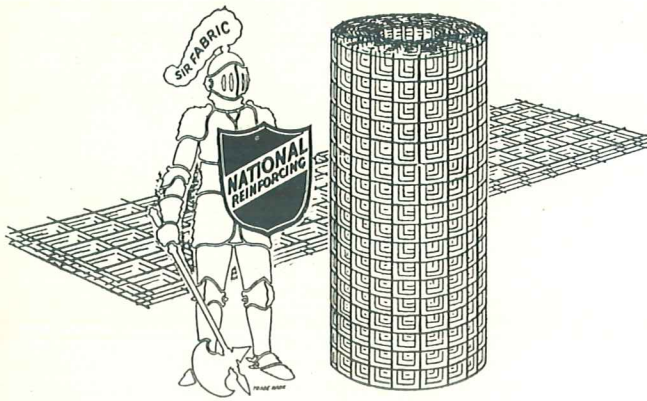
UNION TRUST BUILDING   PITTSBURGH, PA.

OFFICES AND WAREHOUSES: ATLANTA CHICAGO CINCINNATI CLEVELAND DETROIT HOUSTON
LOS ANGELES NEW YORK CITY PHILADELPHIA PITTSBURGH PORTLAND ST. LOUIS
SAN ANTONIO SAN FRANCISCO SEATTLE SYRACUSE

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Foreword

THE remarkable industrial and civic growth of the United States in recent years has involved, in all basic industries and especially in the building industry, activities and developments of the highest order. The machinery and processes of manufacture, the materials and methods of construction have all been passing through a cycle of development marked by the advent of ingenious mechanical inventions, perfection of revolutionary processes, and searching scrutiny into the structural and economic fitness of building materials to meet the most exacting requirements of strength and durability. The complexities of modern commercial intercourse have created segregated centers of dense population requiring the erection of large compact buildings to house the social and business activities of the community. This need for buildings of the larger and better kind is evidenced by the prolific erection of that type of structure exemplified in the modern office building, hotel, school, or apartment block. Whether provided with limited or extensive facilities, whether given the simplest or most elaborate architectural embellishment, the one impelling motive of design, in this class of building, has consistently been to provide substantial, durable, fire-resistant construction.

In this development of fireproof construction (recording, as it does, experimentation with many different materials and innumerable methods of their application and assembly), concrete, or more particularly *reinforced concrete*, is undoubtedly the outstanding building material; concrete has been proved, by time and universal usage, to combine, in greatest measure, all of the desired qualities of strength, economy, durability, and resistance to fire. The universal and varied adaptability of concrete as a building material has been rendered possible only by using it in combination with steel to reinforce it against tensile stresses, and by the subsequent development of a rational theory of design as a means of properly proportioning the composite material known as *reinforced concrete*.

The economy and efficiency of concrete as a building material, therefore, has been largely a matter of its proper reinforcement. In adapting the material to its various structural uses, numerous types and arrangements of reinforcing steel have been devised, some of which offer distinct advantages in beams and columns while others, by virtue of special fabrication, are best adapted to the reinforcing of slabs. Prominent among the factory fabricated types of reinforcement is National Reinforcing, a welded wire mesh not only adaptable to a great variety of uses but also possessing unusual merit as an efficient and economical reinforcement for all kinds of slab construction, particularly for the floor and roof slabs of the modern fireproof building. Without, in any way, attempting to suggest the many and varied uses of National Reinforcing, the subject matter of this publication is confined wholly to a discussion of some of the more common types of slab construction as used in buildings, with special reference to the application of National Reinforcing thereto.

Mathematical computation of the stresses developed under given combinations of span and loading, in the case of slabs, results merely in the selection of the proper thickness of slab and the required cross-sectional area of steel. This, in general, comprises the prevalent conception of slab design. While the determination of these important quantities is necessary and indeed fundamental to the strength of the slab from the standpoint of its load carrying capacity, there are, nevertheless, other essential phases of design which are not susceptible of mathematical derivation but which have a most important influence upon the economy, rigidity, fireproofness, and durability of the construction. These phases of slab design, which cannot be "figured," comprise such features as the location and distribution of the steel, its proper fireproofing, provision for shrinkage and temperature stresses, simplicity of erection, and other problems, the proper solutions of which are necessarily dependent upon the experience of the designer and his familiarity with the best standards of engineering practice.

The purpose of this book, therefore, is to present certain tables and data which will simplify much of the tedious processes of computation, and also to discuss some of the more important phases of slab design from the standpoint of practical considerations of economy and structural efficiency. The extensive and successful use of National Reinforcing over a long period of years offers ample justification for the data and information herewith presented, and should assure their acceptance as not only authentic and reliable, but also indicative of the best practice of the day in this class of construction.

Reinforced Concrete Floors

TYPES OF CONSTRUCTION

BEAM-AND-SLAB FLOORS—The beam-and-slab type of floor consists of a solid concrete slab supported by floor beams of either reinforced concrete or structural steel. This design lends itself readily to a wide range of structural requirements and offers many distinct advantages from the standpoint of strength, economy, and simplicity of erection. This type of construction is particularly adapted to and extensively used in that class of buildings typified by the modern hotel or office building, wherein permanent and fire-resistant qualities are of paramount importance.

In the larger cities, where land is very valuable and it consequently becomes necessary to erect buildings of considerable height, it is almost the invariable practice to design the supporting frame; that is, all beams, girders, and columns, of structural steel rather than of reinforced concrete. The all-concrete building cannot be satisfactorily adapted to very high structures because of the extremely heavy sections required for foundations and for the lower tiers of columns; incurring thereby not only high initial construction costs but also reducing materially the net usable floor space in the lower stories.
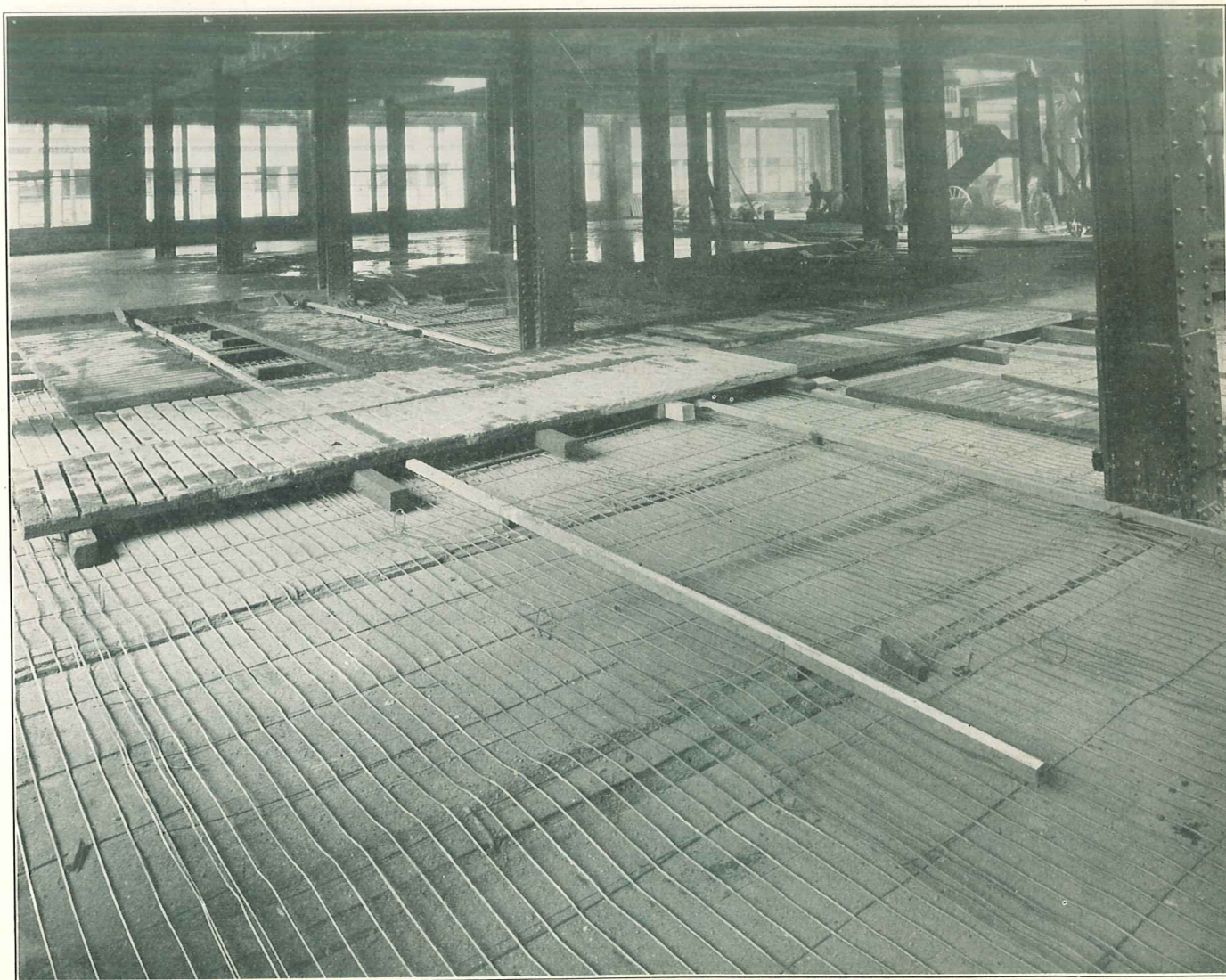
NATIONAL STEEL FABRIC USED AS FLOOR SLAB REINFORCEMENT.   OFFICE BUILDING AT 6TH AVE. AND SMITHFIELD ST., PITTSBURGH.

The steel framing for buildings of the ordinary civic type, such as office buildings, loft buildings, hotels, and large apartment houses, is well standardized as to general arrangement of members. Columns are spaced so as to give approximately square bays of 18 to 24 feet, the most common spacing being about 20 feet. Girders, arranged along column lines in one direction only, support the floor beams which in turn carry the solid concrete floor slab. In buildings of this kind, where it is important to keep dead weight as low as possible, it is desirable to use the thinnest practical floor slab, if possible not more than 4 inches, and for that reason wide-spacing of floor beams is usually avoided. As commonly built, a floor beam is located on column centers with two intermediate beams between columns, thereby dividing each bay into three panels and resulting in slabs having relatively short spans of from 6 to 8 feet. In buildings of moderate height, however, whether framed in steel or in concrete, and where dead weight is not a dominant factor, wider spacing of floor beams, with a correspondingly thicker slab, often proves advisable. In any specific case, however, the most economical spacing of beams, judged on the basis of cost alone, is best determined by tentative designs and estimates involving the relative cost of beams as compared with the cost of slab.

When the framing is of structural steel, the beam-and-slab type of floor affords a very distinct advantage over other types in that all floor forms, including the boxing necessary for fire-proofing around beams and girders, may be suspended directly from the structural steel floor members. This eliminates entirely the use of any shoring or studding under floor forms, thus increasing greatly the speed with which the concreting can follow the steel erection and leaving each floor clear and un-obstructed while pouring the floor above. Ability to quickly use the entire area of each floor, without the long delay other-wise required in waiting for the removal of temporary shoring or studding, is extremely important in the congested business centers of large cities where practically no exterior space is available and it consequently becomes necessary to rely almost wholly upon the completed floor space within the building for all handling and storing of materials.

Cinder-concrete is admirably adapted to this type of design, when the framing is of structural steel. By using steel shapes for all beams, girders, and columns, the cinder-concrete is utilized only for the slabs (which are of relatively short span) and also as the fireproof covering for the structural steel. This combination of materials is extremely economical and, because of the light weight of cinder-concrete, effects a very material saving in the necessary sizes of columns and founda-tions. A better appreciation may be had of the real magnitude of this saving when it is realized that a 4-inch slab of cinder-concrete weighs approximately 14 pounds per square foot less than a stone-concrete slab of the same thickness. This unit, together with a corresponding reduction in weight for the fireproofing around all beams, girders, and columns, mounts

to a very imposing total when summed up throughout the complete interior of a modern office building of some fifteen or twenty stories.
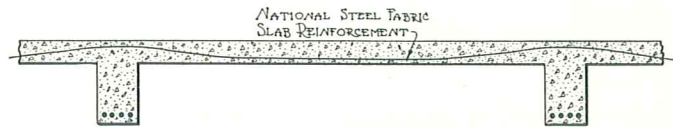
Fig. 1. Slab with Floor Beams of Reinforced Concrete

Typical floor sections are illustrated by Figure 1 showing slab with floor beams of reinforced concrete and Figure 2 with steel I-beams encased in concrete. In Figure 1 the entire beam, and in Figure 2 the concrete beam covering are poured monolithic with the slab. Continuity of slab action is obtained by locating the reinforcement in the bottom of the slab at the center of each span and in the top of the slab over the beams. As a means of facilitating correct location of the steel and also of assuring its proper distribution throughout the slab, the fabricated mesh type of reinforcement offers many distinct advantages, as compared with loose bars, not only in the matter of reinforcing efficiency but also from the standpoint of economy, simplicity, and speed of installation.
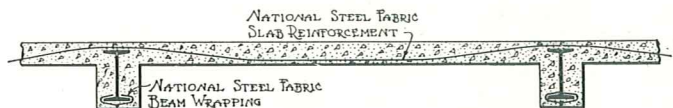
Fig. 2. Slab with Steel Floor Beams Encased in Concrete

Where the floor beams are of reinforced concrete, elevation of the wire fabric over the beams is obtained either by setting precast concrete blocks on the forms at each side of the beam or by placing, on each side of the beam opening, longitudinal runner bars supported by metal chairs or clips fastened to the forms. Where the floor beams are of steel, the I-beam is usually located about 1 to 1½ inches below the top surface of the slab. With this arrangement, the desired location of the reinforcement is readily obtained by simply rolling out the wire fabric over the beams and allowing it to droop to the bottom of the slab between beams. At the center of the span the fabric is kept clear of the forms by inserting small pebbles under an occasional wire or by working the fabric up gently be means of a wire hook while the concrete is being poured. It is apparent that the simplicity of this procedure in placing welded fabric is in marked contrast to the laborious and costly operations of spacing, wiring, supporting, bending, and splicing necessitated when loose bars are used.

When steel floor beams and girders are used, it is necessary to encase them in concrete for fireproofing purposes. The concrete haunch, which surrounds the web of the I-beam, as
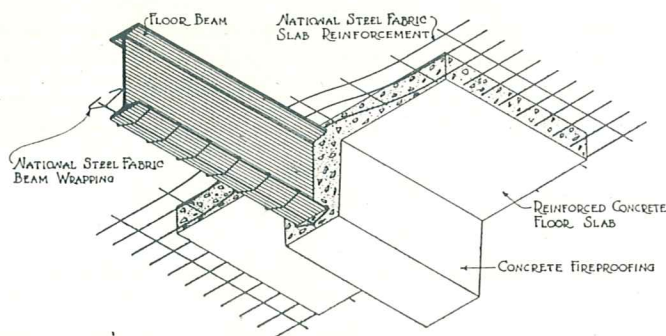
Fig. 3.   Isometric View Showing National Steel Fabric
Slab Reinforcement and Beam Wrapping

usually built, does not require reinforcement, since this con‐crete rests directly upon the bottom flange of the beam and is well supported laterally by the floor slab above.   The thin layer of concrete below the bottom flange, however, has a tendency to flake off and requires, therefore, sufficient rein‐forcement to tie it into the concrete haunch above.   This is best accomplished by wrapping the bottom flange of the I‐beam with welded wire fabric.   The fabric is furnished in rolls, from which narrow sheets are cut and bent around the bottom flange as shown in Figure 3.   The members extending around the flange usually correspond to the longitudinal wires of the roll, and have as a rule closer spacing than the transverse wires which run crosswise of the roll.   One of the transverse members welded to each longitudinal is shown, in Figure 3, extending along the under‐side of the beam.   This serves as a spacer for the main reinforcing members, thus enabling a long sheet of the fabric to be placed in one operation.

RIBBED FLOORS—The "ribbed" floor consists of a thin concrete slab cast monolithic with comparatively small sup‐porting ribs or joists having relatively close spacing.   This

Fig. 4.   Ribbed Floor with Exposed Ribs

arrangement is, in effect, nothing other than a combination of beam and slab, but differs from the so‐called beam‐and‐slab floor, described above, in that a series of very shallow and closely spaced T‐beams span directly between girders, thereby eliminating the relatively deep floor beams of the other type. As commonly used, the ribbed floor is constructed by two general methods; that in which the joists are left as exposed ridges on the bottom of the slab, and that in which terra cotta or gypsum tile are set between ribs thereby giving a flat surface to the bottom of the slab.

In the floor having exposed joists (Figure 4), the necessary forms or "centers" for forming the slab and ribs are usually inverted pans of light gauge metal which remain permanently in place.   Removable forms of a more substantial character, either of metal or of wood, are frequently employed to advan‐

tage by re‐using them a sufficient number of times to justify the additional expense involved.   When the ribs are left exposed, flat ceilings are obtained by furring across the ribs and applying metal or wire lath and plaster thereto.   In the open‐rib floor the joists or "ribs" are usually spaced 20 inches in the clear, which, with a rib thickness of 4 to 6 inches, gives common spacings of 24 to 26 inches center to center of ribs.   The top slab has a thickness of from 2 to 3 inches and the total depth of rib varies from 8 to 17 inches depending upon span and loading.
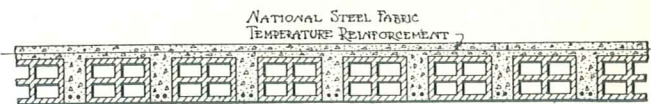
Fig. 5.   Ribbed Floor with Hollow Tile Centers

The other type of ribbed floor consists of a combination of concrete and hollow tile, as illustrated in Figure 5.   In this method of construction, the tile serve as forms for the slab and for the sides of each rib.   The tile remains permanently in place and, being set flush with the bottoms of the ribs, provide a flat surface to which plaster can be directly applied without the need of any furring and lathing.   When built with tile centers, ribs are usually spaced 12 inches in the clear to accom‐modate the standard 12‐inch tile.   Ribs are generally 4 inches wide, thus giving the customary spacing of 16 inches center to center of ribs.   The top slab is usually 2 to 3 inches thick, while the total depth of rib varies from 6 to 15 inches depending upon span and loading.

The ribbed floor is best adapted to spans ranging from 15 to 25 feet and for relatively light loads.   By eliminating floor beams, the ribbed floor affords a simple, and often economical, means of obtaining flat plastered ceilings, especially when provided with hollow tile centers.   As compared with the beam‐and‐slab type of construction, however, this feature may not necessarily prove a structural advantage.   Where deep floor beams are used, flat ceilings are obtained by employing a suspended ceiling, which, although relatively expensive in furring and lathing, provides, between ceiling and slab, very convenient and often necessary spaces for the concealment of ducts, pipes, and conduits.

The ribbed floor in general weighs somewhat more than the beam‐and‐slab type designed for similar conditions.   The difference may be 10 to 30 pounds per square foot when stone‐concrete is used, and possibly as much as 40 or 50 pounds per square foot if the beam‐and‐slab floor is constructed of cinder‐concrete.   This is a very important consideration, particularly in high buildings, as this difference has a material influence on the dimensions required for all girders, columns, and founda‐tions.

The ribbed floor always requires reinforcement for tempera‐ture and shrinkage stresses, because of the slight resistance offered by the thin slab against contraction in a direction
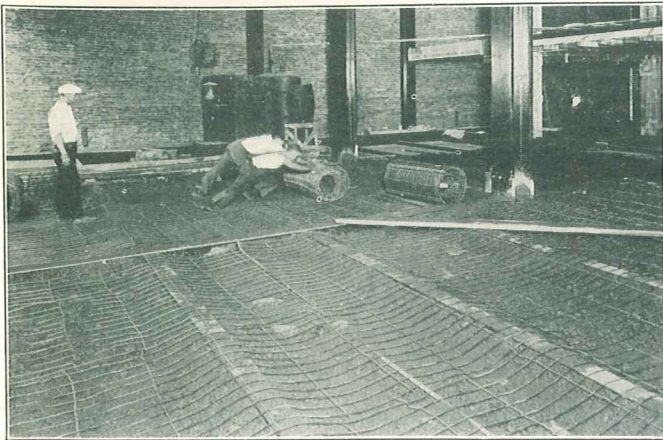
A NEW YORK CINDER-CONCRETE FLOOR JOB

transverse to the ribs. Reinforcement for this purpose is usually laid flat and located just far enough above the bottom of the slab to assure its proper embedment and fire protection. Undoubtedly the most efficient type of temperature reinforcement for the ribbed floor is a wire fabric of the welded type wherein the main members have a spacing of 4 to 6 inches. Welded wire fabric, with comparatively small members relatively closely spaced, assures adequate steel distribution so necessary to the efficient resistance of temperature stresses, and for such purposes is undoubtedly better adapted than loose bars perhaps of the same or greater total cross sectional area but spaced 18 or 24 inches apart. Furthermore, the economy and facility with which welded fabric can be placed, by simply rolling out wide widths across the entire building, as compared with the slow and costly process of placing innumerable individual bars, would commend welded fabric as the ideal reinforcement for the thin tops of ribbed floors.

GROUND FLOORS—The ground floor, so-called, is nothing more or less than a concrete slab laid directly upon ground which has been graded, levelled and otherwise properly prepared to serve as a suitable subgrade foundation for the slab. This is the customary construction for practically all basement floors or for first floors of industrial buildings where basements are usually omitted. The success of the ground floor slab is positively dependent upon two provisions; namely, proper treatment of the subgrade, and adequate reinforcement of the slab.

The subgrade should have a reasonably uniform bearing power since extreme variations of hard and soft spots introduce the danger of serious cracks in the finished floor by reason of uneven settlement of the slab. In preparing the subgrade it is therefore important to remove all soft and spongy places and fill all depressions with suitable material thoroughly rolled or tamped to a firm and level surface. If natural drainage is poor, so that the sub-grade may become saturated with water, a suitable drainage system may be required, not only to prevent

settlement but also, in the case of basements, to insure water-tightness. The concrete slab may be laid directly upon the subgrade if it consists of sand or gravel; if not, a layer of coarse, durable material, such as gravel or steam boiler cinders, is usually spread and thoroughly compacted by wetting, rolling or tamping to a thickness of at least 6 inches.

Because of the indeterminate nature of the stresses occurring in a slab of this kind the best practice requires reinforcement, usually located about 2 inches below the top of the slab, as a safeguard against excessive cracking; primarily, however, this reinforcement serves to maintain the integrity of the slab against progressive disintegration, should cracks appear as the result of settlement or shrinkage. Contraction, due to temperature changes, will induce high tensile stresses in any slab laid directly on the ground, because of the frictional resistance between the slab and the subgrade. Since this movement may occur in either direction, it is obvious that the ground slab requires reinforcement both longitudinally and transversely. This requirement is most effectively and economically met by the use of welded wire fabric wherein longitudinal and transverse members, of any required size or spacing, are arranged at right angles to each other and rigidly welded together at every intersection.

Ground floors are usually constructed by depositing concrete over a certain area and rough screeding the concrete to a depth of approximately 2 inches less than the finished thickness of slab. One or more sheets of welded fabric are then placed, adjoining sheets being lapped about one mesh, and followed up immediately with deposition of the remaining 2 inches of concrete. This may be carried on as a continuous process, resulting in monolithic concrete throughout, except where construction joints are required at the close of the day's work or because of a prolonged shut-down of the mixer. Aside from its structural efficiency, the construction advantages of
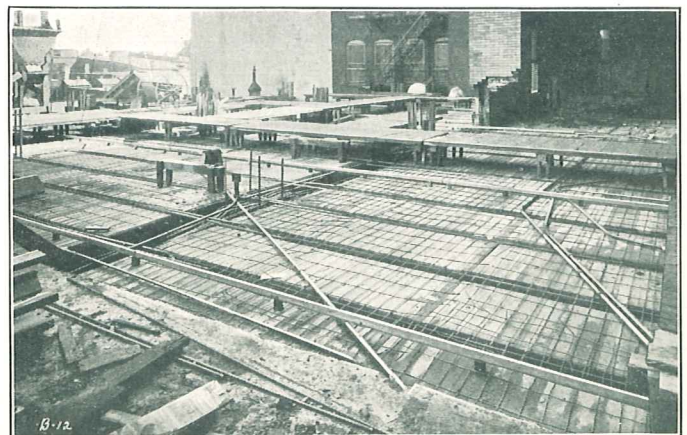
UNITED BRETHREN BUILDING, DAYTON, OHIO

welded fabric over loose reinforcing members are apparent for work of this kind. Because of its special fitness and its unusual adaptability to ground floor requirements, welded fabric has become the recognized standard of reinforcement, not only for ground floors in buildings, but also for that entire class of construction, such as sidewalks, roads, etc., wherein sizeable slabs of concrete are laid directly on the ground.

FLOOR SURFACES

GENERAL REQUIREMENTS—The concrete floor slab of a building, as poured and screeded to its proper structural thickness, always requires some sort of surface treatment to render it suitable for its intended use. This treatment may consist of no more than a rough floating or troweling of the surface before the concrete has hardened, or it may involve a more or less elaborate application of additional materials subsequent to completion of the slab. The adaptability of any type of floor surface to meet given conditions may be judged by the degree in which it provides essential surfacing properties; such as, (a) low cost, (b) small upkeep, (c) durability, (d) resistance to abrasion, (e) resiliency, (f) non-dust producing, (g) quietness, (h) non-slipperiness, (i) sanitation, (j) appearance.

The relative importance of each item in any classification of floor properties is entirely dependent upon the character of the building and the purposes for which it is to be used. For a given class of occupancy, some one property will usually be of paramount importance; as for example, the necessity of "sanitation" in hospitals, "non-dusting" in factories equipped with delicate machinery, or even "appearance" in cases where it is necessary to obtain certain colors, designs, or finish appropriate to the desired architecture of the building.

TYPES OF SURFACES—There is no definite criterion as to what in general constitutes the best type of floor surface, since any type, although offering distinct advantages under certain conditions, may prove unnecessarily expensive, inadequate, or undesirable for some other usage. The floor surfaces most commonly used are of two fundamental types, (a) granolithic, (b) wood; each of which may be developed in a variety of ways to meet different requirements. Use is also made of numerous special or proprietary floor surfaces, such as asphalt, magnesite composition, leatherboard, and various kinds of tile.

GRANOLITHIC FLOORS—Granolithic finish is a mixture of cement, sand, and stone applied as a wearing course the concrete slab. If possible, it should be placed before the slab has hardened appreciably, in order to insure perfect bond and a practically monolithic floor. The granolithic surface should be laid not less than $\frac{3}{4}$ inch in thickness and should consist of a mixture of one bag of cement, one cubic foot of sand, and one cubic foot of coarse aggregate. The coarse aggregate, as usually recommended, is graded crushed rock which will completely pass a $\frac{3}{8}$ inch screen and have at least 90% retained by a

$\frac{1}{4}$ inch screen. The mixture should be of the driest consistency possible to work conveniently with a sawing motion of the strikeboard or screed.

After screeding to the established grade, the surface should be worked with a wood float thereby smoothing out all inequalities and compacting the surface but without drawing an excess of fine particles to the top. A much smoother surface may then be obtained by finishing with a steel trowel, but precaution should be taken against excessive troweling which works the fine particles to the surface. Not being firmly cemented together, these fine particles would later loosen easily under traffic and cause objectionable dusting. As soon as the surface has hardened sufficiently it should be protected against too rapid drying by covering with damp sand or by flooding with water.

In case the wearing course cannot be laid until after the slab has hardened, or when it is necessary to renew the wearing surface of an old floor, special precautions should be taken to prepare the previously poured concrete base before applying the granolithic finish. The surface of the slab should be roughened by "picking" or other means, cleaned of all dirt and debris, and followed immediately by thorough moistening. However, the surface should be kept free from pools of water, and brushed with a neat cement grout of creamy consistency immediately before applying the wearing course. The same process of mixing, laying, and finishing the granolithic surface is then followed as described above.

A well laid granolithic surface is probably the most economical of all floor surfaces. It will withstand exceptionally severe wear, will give long service, is clean, cheap, and easily renewed. Some of the objections usually advanced against granolithic floors are their hardness (particularly as experienced by standing operatives in factories), susceptability to dusting, noisiness, slight difficulty offered in attaching machinery, and slipperiness when wet.

TERRAZZO FLOORS—Terrazzo may be classified as a form of granolithic surface in that it is essentially a poured cement-bound finish applied to a concrete slab. It differs, however, from the usual granolithic floor surface in that the wearing course contains a large proportion of irregular marble or granite particles and its final finish is obtained by grinding to a smooth surface instead of troweling. Terrazzo is laid in two courses which should have a combined thickness of not less than 2 inches. The first, or binder course, consists preferably of a 1:3 cement-sand mortar and is laid 1 to $1\frac{1}{4}$ inches thick. The finish course is laid $\frac{3}{4}$ to 1 inch thick and consists of cement and stone or marble chips using just enough cement to properly fill the interstices of the aggregate mixture.

As in any type of granolithic surface the best results are obtained with terrazzo by placing the binder course before the structural slab has hardened. This, however, is rarely

possible with terrazzo floors, because of the resulting delay to the construction. The binder course, therefore, is usually laid after hardening of the slab which must receive the same preparatory treatment of roughening, wetting, and grouting as described above for the "laid after" type of granolithic surface. Placing of the finish course is frequently delayed, but every effort should be made to have it follow immediately after completion of the binder course, to insure the best results. After the mixture of cement and chips is spread evenly to the proper thickness, it is rolled; then additional marble chips, of the desired color and size, are spread over the surface and rolled in until chips constitute at least 85% of the surface. After the finish course has taken a hard set, but before it gets too hard, it should be ground to a smooth, even surface by a rotary rubbing machine, or by hand, using carborundum brick.

The terrazzo floor is used principally in lobbies, show rooms, corridors and toilets. It lends itself to a great variety of color and mosaic effects which are obtained by the use of different colored chips and the admixture of mineral coloring matter; various patterns and borders may be developed by block configurations of contrasting color. Terrazzo, although somewhat more expensive than an ordinary granolithic surface, is considerably less expensive than marble tile with which it compares very favorably in the matter of appearance. A well laid terrazzo floor is clean, sanitary, attractive in appearance, and, under foot traffic, extremely durable.

Since terrazzo is used primarily with the object of obtaining a floor surface which will be attractive in appearance, every precaution should be taken to safeguard it against the formation of unsightly cracks which tend to develop as the result of shrinkage or contraction due to temperature changes. As a precautionary measure in this regard, reinforcement is frequently used in the form of a light wire fabric placed in the binder course. National Reinforcing is extensively and successfully used for this purpose, the style of fabric being either a 2-inch square mesh with No. 14 gauge wires, or a 4-inch square mesh with No. 12 gauge wires.

WOOD FLOORS—To overcome, principally, the objections of hardness and noise, and, in certain types of buildings for the sake of appearance, concrete floor slabs are frequently provided with a wood wearing surface. Application of such a surface is usually accomplished by covering the slab with a 2-inch layer of lean cinder-concrete fill, in which 2 x 4 inch bevelled wood sleepers are embedded at intervals of about 16 inches on centers (see figure 6). Heavy building paper is then placed

over the sleepers and cinder-concrete (in the better class of construction), and covered with 1-inch hardwood flooring
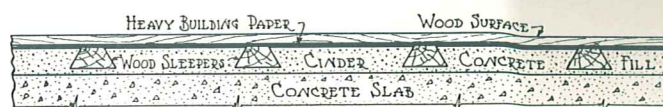
Fig. 6. Usual Method of Applying Wood Floor to Concrete Slab

securely nailed to the sleepers. Sometimes added strength is obtained by placing a diagonal sub-flooring securely nailed to the sleepers. Sometimes added strength is obtained by placing a diagonal sub-flooring of 1 inch soft wood between the sleepers and the top flooring. In cases where trucking or the attachment of light machinery must be provided for, this sub-flooring frequently consists of 2-inch planks.

Another type of wood surface, frequently used in industrial buildings, is that in which the wood sleepers and cinder-concrete fill are omitted, the top of the slab being covered with a mixture of hot tar and sand upon which the 2-inch planks of the sub-flooring are laid. To the planks is then applied a 1-inch diagonal intermediate floor which in turn is covered with 1-inch hardwood flooring. This type of floor provides solid support against the slab, and is therefore well adapted to heavy trucking and to the attachment of machinery. However, it has practically no anchorage to the slab (as is provided by the embedded sleepers in the foregoing type), and for that reason sometimes has a tendency to twist and warp during the drying out of the building.

WOOD BLOCK FLOORS—Wood blocks, treated with preservative, provide a very satisfactory floor surface under some conditions. The blocks are laid directly upon the concrete slab which has previously been spread with a comparatively thin coating of coal tar pitch. Wood block floors are almost entirely restricted to use in industrial buildings, a 2-inch block being used for light traffic and 3-inch blocks for the heaviest service.

The wood block floor has exceptional durability under the most severe trucking conditions providing truck wheels have fairly wide tires to prevent actual cutting into the end grain of the wood. This type of floor is also resilient, noiseless, dustless, and non-slippery. It has the disadvantages, however, of being extremely dark in color and of providing an insecure anchorage for machinery.

Design of
Reinforced Concrete Floor Slabs

THEORY OF FLEXURE

ASSUMPTIONS—The commonly accepted theory of flexure as applied to the design of reinforced concrete beams is based upon the following fundamental assumptions:

(a) Calculations are made with reference to working stresses and safe loads rather than with reference to ultimate strength and ultimate loads.

(b) A plane section before bending remains plane after bending, shearing distortions being neglected.

(c) The modulus of elasticity of concrete in compression is constant within the limits of working stresses, the distribution of compressive stress in beams therefore being rectilinear.

(d) In calculating the moment of resistance of reinforced concrete beams the tensile resistance of the concrete is neglected.

(e) Bond between the concrete and the steel reinforcement remains unbroken throughout the range of working stresses.

(f) Initial stress in the reinforcement due to contraction or expansion of the concrete is neglected.

NOTATION—This publication considers only that type of slab classified as a beam of rectangular cross-section reinforced for tension only. Derivation of the various formulas used in the design of reinforced concrete slabs of this type involve the following notation:

f_s = tensile unit stress in steel.
f_c = compressive unit stress in concrete.
E_s = modulus of elasticity of steel.
E_c = modulus of elasticity of concrete.
$n = \dfrac{E_s}{E_c}$ = ratio of moduli of elasticity.
M = bending moment, or moment of resistance.
A_s = sectional area of steel. (For 12 inch width in slabs.)
b = breadth of beam. (Taken as 12 inches in slabs.)
d = depth of beam to center of steel.
k = ratio of depth of neutral axis to depth d.
j = ratio of lever arm of resisting couple to depth d.
$p = \dfrac{A_s}{bd}$ = steel ratio.
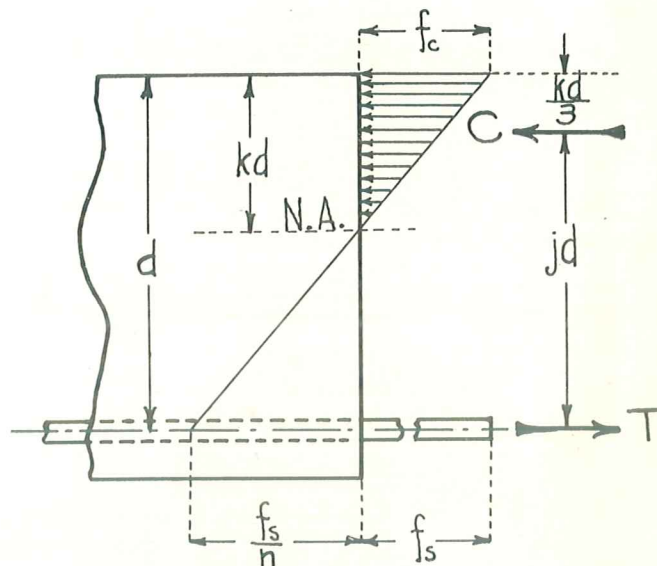
Fig. 7. Stress Distribution in Rectangular Beam

FORMULAS—Based upon the foregoing assumptions the common theory of flexure develops the following formulas:

Position of neutral axis,
$$k = \sqrt{2\,pn + (pn)^2} - pn \dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Arm of resisting couple,
$$j = 1 - \frac{k}{3} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2)$$

Compresive unit stress in extreme fiber of concrete,
$$f_c = \frac{2\,M}{jkbd^2} = \frac{2\,pf_s}{k} \dots\dots\dots\dots\dots\dots\dots\dots (3)$$

Tensile unit stress in longitudinal reinforcement,
$$f_s = \frac{M}{A_s jd} = \frac{M}{pjbd^2} \dots\dots\dots\dots\dots\dots\dots\dots (4)$$

Steel ratio for balanced reinforcement,
$$p = \tfrac{1}{2}\,\frac{1}{\dfrac{f_s}{f_c}\left(\dfrac{f_c}{nf_s}+1\right)} \dots\dots\dots\dots\dots\dots (5)$$

LOADS

DEAD LOADS—Dead loads include the weight of all permanent parts of the structure. In the case of floor and roof slabs the dead load consists of the weight of the slab and the floor or roof surfacing such as cinder fill, wood planking, terrazzo, linoleum, tile, roofing material or plastering if applied directly to or supported by the slab.

Partitions, except in the case of permanent immovable walls, the exact weights of which can be provided for on the basis of definite locations, are usually considered as a uniformly distributed floor load of 20 to 25 pounds per square foot. This load is considered as uniformly distributed on the assumption that any portion of a floor may, at some future date, be required to sustain the weight of partitions as the result of a subsequent rearrangement or subdivision of the floor area.

Dead loads commonly involved in the design of ordinary floor and roof slabs are as follows:

WEIGHTS OF MATERIALS

FLOORS		Weight in lbs. per sq. ft.
Maple Flooring	(per inch thickness)	4
Spruce	" " "	2½
Cinder Concrete Filling	" " "	5
Granolithic Finish	" " "	12
Stone Concrete	" " "	12½
Cinder Concrete	" " "	9
Asphalt Mastic Flooring, 1½ Thick		18
3" Creosoted Blocks on tar base		21
Solid Flat Tile on 1" mortar bed		23

CEILINGS	
Plaster on tile or concrete	5
Suspended metal or wire lath and plaster	10

ROOFS	
Five-ply felt and gravel	6
Three-ply ready roofing	1
Cement tile	16
Slate, ¼" thick	9½
2" Book tile	12
Skylight with iron frame and ⅜" glass	6
Gypsum, 3" slab	13

LIVE LOADS—Live loads, which are usually of a movable or variable character, include all loads and forces applied to the structure other than the dead load. In the case of floors and roofs of buildings located in the larger centers of population, the live load is definitely fixed by the local building code as a uniformly distributed load in pounds per square foot.

Comparison of the building codes of various cities reveals a most astonishing variation in live loads specified for various kinds of occupancy in buildings. An interesting analysis of building code requirements was recently made by the Building Code Committee of the United States Department of Agriculture, covering approximately one hundred cities of the United States. Results of this investigation disclose such wide differences in the code requirements of various cities for the same class of occupancy, as to indicate either the existence of many antiquated laws or a wide divergence of opinion among authorities as to what constitutes proper loadings for various classes of buildings. The requirements of a number of leading cities are herewith (see page 12) presented although, before proceeding with any design, it is important to ascertain the latest local requirements which are always subject to periodic changes through special rulings as to classification.

BENDING MOMENTS

NOTATION—Formulas for bending moments in slabs carrying uniformly distributed loads involve the following notation:

M= bending moment in general.
w= load per unit length of span. (In slabs where width of beam section is taken as 12 inches and span unit is in feet, w= pounds per square foot.)
l= span of slab.

SPAN LENGTH—The span length of freely supported slabs should be the distance between centers of supports, but need not exceed the clear span plus the depth of slab. The span length for continuous or restrained slabs may usually be taken as the clear distance between faces of supports unless otherwise defined by the building code for the specific locality in question.

MOMENT FORMULAS—Slabs of equal spans built to act integrally with beams, girders, or other partially restraining supports and carrying uniformly distributed loads are commonly designed for the following moments at critical sections:

(a) Slabs of one span.
Maximum positive moment near center,
$$M = \frac{wl^2}{8}$$

(b) Slabs continuous for two spans only.
1. Maximum positive moment near center,
$$M = \frac{wl^2}{10}$$
2. Negative moment over interior support,
$$M = \frac{wl^2}{8}$$

(c) Slabs continuous for more than two spans.
1. Maximum positive moment near center and negative moment at support of interior spans,
$$M = \frac{wl^2}{12}$$
2. Maximum positive moment near centers of end spans and negative moment at first interior support,
$$M = \frac{wl^2}{10}$$

SLABS SUPPORTED ON FOUR SIDES—Slabs having the supports extending along the four sides should be designed and reinforced as continuous over the supports. If the length of the slab exceeds one and one half times its width, the entire load should be carried on the short span. If the length of slab is not greater than one and one-half times its width, the proportion of the total load to be carried on the short span may be determined by the formula $r = \frac{a}{b} - 0.5$ where a = length and b = width of slab. The remainder of the total load should then be assumed as carried on the long span.

LIVE LOADS REQUIRED BY BUILDING CODES

OCCUPANCY		Atlanta	Boston	Chicago	Cleveland	Denver	Detroit	Los Angeles	Minneapolis	New Orleans	New York	Philadelphia	Pittsburgh	Saint Louis	San Francisco	Seattle
		LIVE LOAD IN POUNDS PER SQUARE FOOT OF FLOOR														
Dwellings	1st Floor	60	50	40	60	40	50	50	50	40	40	40	40	50	60	40
	Above	60	50	40	60	40	50	50	50	40	40	40	40	50	60	40
Tenements	1st Floor	60	50	40	70	60	80	50	50	40	40	40	80	50	60	40
	Above	60	50	40	70	40	50	50	50	40	40	40	40	50	60	40
Stores (Light)	1st Floor	120	125	100	125	120	125	125	100	125	120	120	125	150	125	100
	Above		125	100	100	120	100	125	100	125	120	120	125	150	125	100
Stores (Heavy)	1st Floor	150	250	100		120	175	125		200	120	120	125		250	100
	Above		250	100		120	175	125		200	120	120	125		250	100
Warehouse	Heavy	250	250	100		200	200	150		200	120	120	200	150	250	
	Light	150	125	100	125	200	130	125	100	200	120	120	200	150	125	
Factories	Heavy	150	250	100		120	130	150		200	120	120	150		250	125
	Light	120	125	100	125	120	130	125	100	125	120	120	125	100	125	
Roofs	Less than 20°	40	40	25	35	40	40	40	50	30	40	30	40	30	30	40
	More than 20°	30	25		30	30	40	25	50	30	30	30			20	
Assembly Halls	Movable Seats	90	100	100	125	120	100	125	125	125	100	100	150	100	125	100
	Fixed Seats	90	100	100	80	120	80	125	125	125	100	100	100	75	75	75
	Drill Halls	150	100	100	150	120	125	150	125	150	100	100	150	150	125	150
	Dance Halls	120	100	100	150	120	125	125	125	150	120	100	150	150	125	100
Schools	Corridors	90	75	75	70	150	90	100	100	60	100	100	100	100	125	50
	Assemblies	90	100	75	80	90	100	125	125	125	100	100	125	100	125	75
	Classrooms	75	50	40	70	75		125	75	60	75	75	60	75	75	50
Office Buildings	1st Floor	150	125	50	125	120	125	125	100		120	100	100	100	125	100
	Above	75	75	50	70	75	75	75	75	70	60	60	60	60	40	50
Public Buildings		90	100		100	150	90	125		125	100	100	100	100		100
Garages	Public	120	150	100	150	150	130	150	100	125	120	120	125	100	100	
	Private	75	75	40	100		60		75	100	120	120			100	60
Hotels	Rooms	75	50	50	70	60	50	50	50	40	40	40	40	50	60	40
	Corridors	150	100	50	125	90	80			70	100	40	80	100	125	40
Hospitals	Wards	75	50	50	80	60	80	50	50	70	40	40	60	50	40	40
	Corridors	90	100	50	80	90	80	100		70	100	40	100	100	40	40
Sidewalks		200	250		200		250		300	300	300		300		150	

Recognizing the fact that in slabs supported on four sides the moment is greater near the center of the slab than near the edges, it is customary to distribute the reinforcement in each direction so that two-thirds of the total sectional area for the panel is located in the center half of the slab and one-sixth in each end of the quarters

ALLOWABLE UNIT STRESSES

STONE-CONCRETE—The maximum allowable working stress for concrete is usually specified as a certain percentage of its ultimate compressive strength at an age of 28 days. It is therefore necessary, before proceeding with the design of any reinforced concrete member, to first establish the grade of concrete by fixing the kind of aggregates to be used and the proportions with which they are to be combined with the cement. The ultimate strength of the concrete may then either be actually determined by testing samples of the exact mixture at 28 days or may be assumed from values found by experience to represent the strength which may reasonably be expected with the particular mixture in question.

The percentage of ultimate strength, whereby working stresses are established, varies somewhat for different requirements. For members subjected to transverse loadings such as slabs, the common value is 32.5%. The assumption that a 1:2:4 stone-concrete of average quality will develop an ultimate compressive strength of 2000 pounds per square inch at 28 days, would fix the maximum allowable compression for purposes of design at 650 pounds per square inch. This value is commonly accepted as representing the best practice to provide for general average conditions in the design of stone-concrete slabs.

CINDER-CONCRETE—Cinder-concrete, although not adaptable to as varied a usage as stone-concrete, is however admirably suited for short span slabs, and as a fireproof covering for structural steel in that type of construction wherein the supporting beams, girders, and columns are of structural steel shapes. The strength of cinder-concrete is of course much less than that of stone-concrete, and is entirely dependent upon the quality of cinders available. In those localities where good steam boiler cinders may be obtained a splendid grade of concrete will result from a mixture approximating 1:2:4, although some adjustment in the proportion of sand content is often necessary to allow for slight excess of fine particles in the cinders. Cinder-concrete of good quality and in about these proportions is usually assigned an allowable working compression of 300 pounds per square inch when used for slabs.

MILD STEEL BARS—Allowable tension in the steel is primarily dependent upon the type and grade of reinforcement used; i.e. whether bars or wire fabric. In the case of bars the allowable working stress is usually taken at approximately one-fourth of the ultimate strength, but limited to an absolute maximum of 18,000 pounds per square inch. For the ordinary structural grade of reinforcing bars this requirement gives the familiar value of 16,000 pounds per square inch which is the customary specification for maximum allowable stress in the steel when the reinforcement consist of bars.

HIGH CARBON BARS—The allowable tension for so-called high carbon bars is usually limited to 18,000 pounds per square inch, regardless of their high ultimate strength. Although a slight saving in the required amount of steel will result from the use of this higher working stress, nevertheless most designers refrain from using high carbon steel for concrete reinforcement because of its extreme brittleness and low ductility. Its brittleness introduces danger of injury to the metal in bending and handling, while its low ductility renders it highly undesirable for structural use particularly in floor slabs which may be subjected to shock, vibration, or the sudden application of concentrated loads.

WIRE FABRIC—From the standpoint of structural adaptability, wire and bars are subject to separate and distinct classifications. Because of certain fundamental differences in the quality and physical properties of the two materials, cold drawn wire is commonly assigned a higher allowable working stress than can be properly given to any grade of hot rolled bars. The cold working of the metal which wire receives through its process of "drawing," by which it is subjected to actual tensile stress while under severe lateral pressure, produces high tensile capacity without sacrifice of its elastic or ductile properties. The process of "drawing" results in every section of a wire being actually tested as to tensile strength, thereby rendering it a more reliable and trustworthy material than the hot rolled bar. Wire drawing, involving as it does the cold drawing of a rod through a die of smaller diameter than the rod itself thus forcing the metal through the die in an undulating, wave-like manner, compresses the fibres into a compact mass thereby eliminating the danger of pits, flaws, or granular sections. Every inch of every strand of wire is thus actually tested in the making; otherwise it could not survive its process of manufacture.

This distinction, as considered wholly from the standpoint of quality and dependability of material, would conservatively justify the practice of utilizing cold drawn wire with an allowable working stress materially in excess of that assigned to hot rolled bars, even though both materials might have substantially the same ultimate strength. As a matter of fact, however, wire fabricated into a welded mesh as commonly used for concrete reinforcement will invariably show an *ultimate* strength considerably in excess of ordinary reinforcing bars, thus affording further justification of the higher allowable stress for wire.

Recognition of the superior properties of cold drawn wire as compared with hot rolled bars, together with the fact that, with a comparable grade of material, the wire will consistently have a higher ultimate strength, has established a working

stress for wire fabric approximately 25% in excess of that permitted for mild steel bars. The generally accepted standard of practice, therefore, is 20,000 pounds per square inch as the proper allowable tensile stress for wire fabric in slab design, a value definitely specified by the building codes of New York and several other leading cities of the country.

SUMMARY OF ALLOWABLE STRESSES—For general average conditions the following allowable working stresses may be considered as representing the best practice for reinforced concrete slab design:

MATERIAL	Allowable Working Stress for Transvere Bending in Slabs				
Concrete (1:2:4 Stone)......Compression	650	lbs.	per	sq.	in.
Concrete (1:2:4 Cinder)..... "	300	"	"	"	"
Bars (Structural Grade).....Tension	16,000	"	"	"	"
Bars (Hard Grade)........ "	18,000	"	"	"	"
Wire (Welded Fabric)...... "	20,000	"	"	"	"

PRINCIPLES OF DESIGN

BEAM-AND-SLAB FLOORS—The thickness of slab necessary to provide proper load carrying capacity in the beam-and-slab type of floor is determined by application of the formulas on page 10, involving analysis of the span, load, conditions of continuity, and allowable stresses in both the concrete and the steel. The actual effort of computation however may be greatly simplified by use of the slab tables offered on pages 18 to 23. While this mathematical determination fixes the minimum depth required for proper load carrying capacity, nevertheless the final selection of slab thickness may be materially influenced by precautionary considerations of strength and simplicity of construction. In cases where short spans and extremely light loads exist, ample transverse strength may possibly be provided with a thickness somewhat less than that which good practice would require for proper rigidity or reasonable economy of construction.

If the slab thickness is less than that prescribed by certain practical limitations, placing of the reinforcement not only becomes a very exacting and costly operation but also introduces an element of structural uncertainty as to strength, since a very slight misplacement of the steel would affect materially the small effective depth of a very thin slab. Considered from the standpoint of stiffness and rigidity, it is generally recognized that, regardless of the amount or character of the superimposed load, a floor or roof slab should, under no conditions, have a thickness less than one-twenty-fifth to one-thirtieth of the span. This requirement, however, is seldom the limiting factor in the final selection of thickness, except possibly in the case of a slab having extremely light loads and designed for a comparatively high allowable stress in the concrete.

In view of these considerations the best practice in floor and roof design of the solid slab type would seem to indicate

a practical minimum for slab thickness of 3 inches for roofs and $3\frac{1}{2}$ inches or preferably 4 inches for floors. It must be realized that these values are considered merely as minimum limitations to assure desirable conditions of construction and safety of design in such cases where unusual combinations of span and loading might otherwise result in extremely light sections if determined solely upon the basis of theoretical computation. In any case, however, proper provision for safe fibre stress under maximum load, as determined by computation, is the primary and usually the governing factor in determining the necessary thickness of slab.

Computed strength of a slab with respect to the reinforcement leads merely to a determination of the cross-sectional area of steel required at the sections of maximum bending moment. This result is expressed in the form of square inches of steel per unit of width which, in the case of slabs, is conveniently taken as one foot. Theoretical computation of strength, therefore, fixes simply the minimum "amount" of reinforcement necessary to assure a safe stress in the steel under maximum loading but prescribes no limitations whatsoever as to its proper "distribution." Having thus determined the necessary quantity of steel, it is of course possible to meet the mere requirement of sectional area by using reinforcing members of any diameter providing they are spaced so as to give the proper area of steel per foot of width. For instance, 1 inch round members spaced on 48 inch centers gives precisely the same sectional area per foot of width as $\frac{1}{4}$ inch members spaced on 3 inch centers. In a typical floor slab of 4 or 5 inch thickness the former arrangement of reinforcement would obviously constitute a very crude and undesirable distribution of steel although it might fully meet the computed requirement for transverse strength.

In order to fulfill its complete function as reinforcement, the steel in slabs should serve not only as structural reinforcement to sustain the superimposed load, but also as a binder to prevent any progressive disintegration of the concrete as the result of possible incipient cracks which, although originally of minor structural importance, might in time become serious unless the steel be so distributed as to prevent their progressive opening. Careful consideration of this secondary function of the reinforcement is essential to good design, particularly in floor slabs, and constitutes purely a problem of proper arrangement and distribution of members rather than mere provision of a predetermined amount of sectional area.

Numerous investigations have definitely proved that the most efficient distribution of slab reinforcement is that which provides comparatively small members having relatively close spacing, rather than large units widely separated. The minimum spacing of members is limited by the space required to permit free passage of the aggregate in the concrete, so that all parts of the reinforcement will be properly covered by and securely embedded in the concrete. A minimum clear opening of $1\frac{1}{2}$ to 2 inches between members is generally considered

necessary in slabs where the coarse aggregate of the concrete is usually limited to maximum size of ¾ to 1 inch. The maximum allowable spacing of members in order to assure proper distribution of the steel is more a matter of good judgment on the part of the designer, since it is neither restricted by definite requirements nor established by uniform practice. Maximum spacing however is frequently judged with relation to the thickness of slab; a practice which has prompted the familiar rule-of-thumb requirement that spacing of main reinforcing members should not exceed the thickness of the slab. In the great majority of cases this restriction would establish a maximum limit of approximately 6 inches.

Good practice for proper distribution of the steel in floors of the beam-and-slab type would therefore indicate a minimum spacing of main reinforcing members of 2 inches and a maximum of 4 to 6 inches, depending somewhat upon the thickness of the slab. The most dependable safeguard for proper steel distribution, however, lies in the election of a distinctive type of reinforcement, such as welded wire fabric; a material especially adapted to slab reinforcement by virtue of its factory fabricated arrangement of members which not only assures proper distribution of its sectional area but also affords maximum facility and economy of installation.

RIBBED FLOORS—From the standpoint of design the ribbed floor is considered as a series of reinforced concrete T-beams spanning the distance between girders. Each rib or joist forms the beam stem to resist shear and is reinforced for tension with the customary longitudinal bars. That portion of the slab adjacent to each rib provides the beam flange necessary to resist the compressive stresses. Owing to the close spacing of ribs, the slab itself requires very little if any reinforcement for transverse strength, especially in that type of floor where permanent tile centers are employed. The thickness of slab is usually fixed by practical considerations of construction or by requirements necessary to provide sufficient compressive section for the T-beam action of the ribs. The minimum practical thickness of the slab in this type of floor, where the steel is used only as temperature reinforcement and therefore laid flat, is generally limited to 2½ inches, or occasionally 2 inches if special care is exercised in levelling up forms and screeding the concrete.

The thin top slab of the ribbed floor always requires reinforcement for temperature stresses. Contraction in a direction perpendicular to the ribs is resisted only by the thin section of the slab, usually not more than 2½ inches thick, and the tensile stresses induced therein may cause serious cracking unless adequate reinforcement is provided. Longitudinally, however, the ribbed floor is much stronger in its resistance to contraction by reason of the ribs with their comparatively heavy longitudinal reinforcement. In this direction, therefore, very little if any reinforcement is required; thus accounting for the common practice of distributing the temperature

reinforcement so that practically all of its sectional area is effective across rather than parallel with the ribs.

The necessary amount of steel required for proper reinforcement of the slab against temperature stresses is established more by standards of good practice than by mathematical determination. A cross-sectional steel area of .04 to .06 square inches per foot length of floor is commonly used in the absence of any definite code regulations. The most important consideration in the selection of temperature reinforcement is the matter of proper distribution of the steel; a relatively close spacing of members is absolutely necessary in order to gain the desired "binder" effect so essential to an adequate resistance of the tensile stresses involved. While there are no definite limitations as to the most effective spacing of reinforcing members, 6 inches may very properly be fixed as the absolute maximum in view of the small slab thickness usually encountered in this type of floor. However, a spacing of 4 inches is probably considered the best practice, as indicated by the extensive use of National Reinforcing for this particular purpose and the pronounced popularity of those fabric Styles having 4 inch spacing of main members.

STYLES OF NATIONAL REINFORCING

Especially Suited for Temperature Reinforcement in Ribbed Floors

Style	Spacing		Gauge of Wire		Sec. Area, Sq. In. per Lin. Foot		Weight Lbs. per 100 Sq. Ft.
	Long.	Trans.	Long.	Trans.	Long.	Trans.	
BF 1012	4″	12″	10	12	.043	.009	19
BF 912	4″	12″	9	12	.052	.009	22
BF 812	4″	12″	8	12	.062	.009	26
BF 711	4″	12″	7	11	.074	.011	31

GROUND FLOORS—A concrete slab laid directly on the ground may very properly be classified in engineering terms, as "Statically indeterminate." This designation implies unknown conditions of support and loading, rendering it impossible to determine, with any degree of accuracy, the stresses in the slab by a rational application of the laws of statics. As distinguished from the structural floor slab supported by a fixed arrangement of beams, the ground slab has no definitely defined beam action since the supporting reactions caused by any superimposed load are distributed over an indefinite area of the subbase and with uncertain intensity. Variations in the bearing power of the subsoil and unequal settlement cause a variable deflection of the slab, which results in bending distortions that tend to rupture the concrete. Furthermore, lateral contraction of the slab due to changes in temperature is restrained by frictional resistance of the subbase, thereby inducing tensile stresses which also tend to crack the concrete.

Ground floor slabs are thus subjected to destructive forces which, although not susceptible of definite mathematical determination, are nevertheless of such a character and magnitude as will in a comparatively short time destroy the utility of the floor unless the concrete is provided with adequate reinforcement. Experience has proved that installation of welded wire fabric is the most effective means of safeguarding the integrity of a ground floor slab. By providing rigidly connected members which distribute the steel equally in both directions, welded fabric reduces cracking to a minimum and positively prevents the progressive opening up of any initial cracks that might possibly occur as the result of shrinkage in setting, temperature changes, uneven settlement, or stresses due to loading. Welded fabric, therefore, acts not only as the structural reinforcement of the slab but also as a binder which toughens the otherwise brittle concrete.

Ground floor slabs are laid from 4 to 6 inches thick with the reinforcement placed about 2 inches below the top surface. Good practice calls for equal reinforcement in both directions, with members spaced 6 inches on centers. Because of the economy and facility with which welded fabric meets every requirement of ground floor conditions it is probably more extensively used, for this class of construction, than any other type of reinforcement. The general Style of fabric most commonly used is practically standardized as a 6 inch square mesh with the same gauge wires in both directions. The size of wire varies from No. 10 to No. 6 gauge depending somewhat upon the character of the subsoil and the nature of the loading. The following Styles of National Reinforcing are suggested as adaptable to varying soil conditions and to a wide range of loading.

STYLES OF NATIONAL REINFORCING

Especially Suited for Reinforcement of Ground Floor Slabs

Style	Spacing		Gauge of Wire		Sec. Area, Sq. In. per Lin. Foot		Weight Lbs. per 100 Sq. Ft.
	Long.	Trans.	Long.	Trans.	Long.	Trans.	
CC1010	6″	6″	10	10	.029	.029	21
CC 99	6″	6″	9	9	.035	.035	25
CC 88	6″	6″	8	8	.041	.041	30
CC 77	6″	6″	7	7	.049	.049	36
CC 66	6″	6″	6	6	.058	.058	42

FIRE PROTECTION

GENERAL REQUIREMENTS—In all construction where steel and concrete are used together, the steel should always be covered with a sufficient amount of concrete to protect it against fire. The design should provide an excess layer of concrete, surrounding the steel, which should have no structural significance and which could be totally destroyed without affecting the strength of the structure. In view of varying recommendations, it is difficult to establish definite values for the thickness of concrete necessary to provide efficient fire-proofing. Regulations covering this work are embodied in the building codes of various municipalities, although many of these differ somewhat for various kinds of construction. A fair working rule for slabs and floor members, however, representing the best practice would seem to be about as follows:

For girders, at least 1½ to 2 inches of concrete outside of all metal; for floor beams, at least 1 to 1½ inches; and for slabs, ¾ to 1 inch.

In that type of floor where the beams and girders are of structural steel fireproofed with concrete, the primary object is to coat the protective layers of concrete as thin as possible in order to reduce the added weight which must be carried by the steel members. Because of the necessarily small thickness of this protective covering, it is, therefore, essential that it be provided with an efficient reinforcement thoroughly distributed through the concrete, and with units occuring at comparatively close intervals, in order to prevent cracking or separation from the steel members. The reinforcement used for this purpose, commonly called "beam wrapping," must be particularly adapted to the thin layers, intricate shapes, and extensive areas involved in work of this kind. The requirements for satisfactory structural steel protection are such that a material used for beam wrapping must necessarily possess the following essential features:

(a) *Fabric type, in order to enable handling and placing in sheet form.*

(b) *Proper size spacing of reinforcing members, to adequately support the concrete.*

(c) *Reinforcing members stiff enough to keep shape when bent.*

(d) *Size and shape of mesh such as to allow unobstructed flow of concrete.*

(e) *Fabric having members rigidly connected, in order to permit cutting into small sheets without ravelling to pieces.*

SELECTION OF BEAM WRAPPING—A wire fabric of the welded type meets every essential requirement as an efficient and economical beam wrapping. Determination of the required size and spacing of wires is not susceptible of mathematical computation. Selection, therefore, is a matter of judgment on the part of the designer and must necessarily be based upon knowledge of fabric Styles which have been found by experience

to give satisfactory results. Proper gauges of wires are governed somewhat by the facility with which the fabric may be applied to the beam as well as by actual requirements of strength. The stress carried by each wire, while indeterminable by rational mathematical analysis, is no doubt relatively small in the great majority of cases, thus making the problem of design more a matter of precautionary arrangement of reinforcement rather than a provision for definite stress involved.

For wrapping the soffits of steel I-beams as occur in the floors of office buildings, hotels, apartments and similar structures, a No. 12 gauge wire has been found to give very satisfactory results and is probably more universally used for this purpose than any other size. In order to obtain a satisfactory distribution of the steel the longitudinal members of the fabric, or those which encircle the bottom flange of the beam, are commonly spaced on 4-inch centers. The transverse members of the fabric, or those which extend lengthwise of the beam, are usually spaced 8 inches on centers; although in some cases, where a more pronounced binder effect is desired, a

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lighter gauge wire is often used with 4-inch spacing both longitudinally and transversely. The best practice in beam wrapping, for average conditions, would thus seem to indicate a fabric 4 x 8 inch mesh with No. 12 gauge wires in both directions.

The following Styles of National Reinforcing are suggested as sizes especially adapted for use as beam wrapping; the several combinations of mesh and sizes of wire affording the designer a wide range of selection to meet any unusual or special conditions peculiar to the specific design.

STEEL COLUMN

NATIONAL STEEL FABRIC
COLUMN WRAPPING

WIRES ELECTRICALLY
CROSS-WELDED

CONCRETE
FIREPROOFING

Fig. 8. Isometric View of
Method of Wrapping A Steel Column

STYLES OF NATIONAL REINFORCING

Especially Suited for Beam Wrapping

Style	Spacing		Gauge of Wire		Sec. Area, Sq. In. per Lin. Foot		Weight Lbs. per 100 Sq. Ft.
	Long.	Trans.	Long.	Trans.	Long.	Trans.	
BB1414	4″	4″	14	14	.015	.015	11
BB1313	4″	4″	13	13	.020	.020	14
BB1212	4″	4″	12	12	.026	.026	19
BD1313	4″	8″	13	13	.020	.010	11
BD1212	4″	8″	12	12	.026	.013	14
BD1112	4″	8″	11	12	.034	.013	17

Tables for Designing Reinforced
Concrete Slabs

EXPLANATION OF TABLES

BASIS OF COMPUTATION—Tables 1-B to 6½-B inclusive (pages 20 to 23) have been computed in accordance with the accepted theory of flexure as applied to reinforced concrete beams of rectangular section, (see formulas page 10). For each slab thickness, there are shown safe total loads in pounds per square foot for various spans and with various cross sectional areas of steel. To obtain the safe applied load; i.e., the load which can be safely applied to the salb other than the slab itself, deduct the weight of slab from the safe total load as obtained from table.

ALLOWABLE STRESSES—Computations have been based upon stone-concrete with National Reinforcing as the reinforcement; i.e., with maximum allowable compression in the concrete of 650 pounds per square inch, maximum allowable tension in the steel of 20,000 pounds per square inch, and ratio of moduli of elasticity of 15.

Loads shown in "bold face type" are for balanced reinforcement; i.e., loads which produce maximum allowable stresses simultaneously in both the concrete and the steel. Loads to left of "bold face column" are limited by tension in the steel, those to right by compression in the concrete.

Loads to left of "heavy vertical line" produce stresses in the concrete which do not exceed approximately 300 pounds per square inch and may, therefore, be safely used for cinder-concrete.

BENDING MOMENTS—Computations have been based upon a bending moment of $M = \dfrac{wl^2}{12}$; i.e., for slabs fully continuous, or with ends fixed.

Safe total loads may be obtained for partially continuous slabs; i.e., for $M\ wl^2$, by taking $\frac{5}{6}$ of loads given in tables;

and for simply supported slabs; i.e., for $M = \dfrac{wl^2}{8}$, by taking

$\frac{2}{3}$ of loads given in tables.

USE OF TABLES

EXAMPLE. No. 1—Required to design a fully continuous stone-concrete slab reinforced with National Reinforcing Slab to have top finished for wearing surface, a span of 7'-6", live load of 100 pounds per square foot and partition load of 20 pounds per square foot.

Total load applied to slab other than its own weight therefore is:

Live load ....100 lbs. per sq. ft.
Partitions............................. 20 " " " "

Total applied load ....120 " " " "

Referring to the tables, the loads shown in bold face type are listed for combinations of slab thickness and steel area which utilize simultaneous maximum allowable stresses in both the concrete and the steel. Proceeding therefore with Table 1-B it is seen that for 7'-6" span the load shown in bold face type is inadequate for our given applied load of 120 pounds. Likewise Table 2-B shows a 3½" slab also to be inadequate since the total safe load of 153 pounds given in this table for 7'-6" span would represent a safe applied load of only 109 pounds after deducting 44 pounds, the weight of a 3½" slab.

Proceeding next to Table 3-B it is seen that a 4" slab is adequate since the value given in bold face type for 7'-6" span shows a safe total load of 214 pounds or a safe applied load of 164 pounds after deducting 50 pounds for the weight of the 4" slab.

Now, it is possible to use less steel area than the theoretical .208 as shown, since 164 pounds is materially more than our required applied load of only 120 pounds. In using a 4" slab the total load to be provided for in our problem is 120 plus the slab weight of 50 pounds or 170 pounds. Following Table 3-B opposite 7'-6" span it is seen that this load requirement is met with a steel area between .160 and .180. Interpolating the proper value for the given load of 170 pounds it is found that .163 square inches of steel are required per foot width of slab.

Referring to Table of Areas page 27, it is seen that No. 4 wires on 3" centers provide a steel area of .160 square inches per foot of width which for practical purposes will meet the requirements of .163. Reference to table of Standard Styles, page 27, shows standard Style of National Reinforcing having No. 4 gauge longitudinal wires spaced on 3" centers to be Style TH49, the transverse wires of which are No. 9 gauge spaced on 16" centers.

The design of the above problem therefore results in the Selection of a 4" slab reinforced with National Reinforcing style TH49.

EXAMPLE No. 2. Given same conditions as in Example No. 1 except design for slab partially continuous; i.e., for $M = \dfrac{wl^2}{10}$

If computed on basis of this bending moment instead of

$M = wl^2$, all loads shown in tables would in each case be $\frac{5}{6}$
of the values shown.

Now proceeding as in Example No. 1 will lead to the selection of a 4" slab as before. Referring therefore to Table 3-B opposite span of 7'-6" under steel area of .200 is given total safe load of 205 pounds. Taking $\frac{5}{6}$ of this load gives total safe load of 171 pounds for condition of partial continuity. As this almost exactly meets the total load requirement of 170 pounds as given, a 4" slab with .200 square inches of National Reinforcing per foot of width therefore is required.

EXAMPLE NO. 3. Required to determine the maximum load that can be safely applied to a 5" stone-concrete slab reinforced with National Reinforcing, Style TH38, having span of 8'-0" and fully continuous.

By table of Standard Styles, page 27, the longitudinal wires of Style TH38 provide a sectional area of steel of .187 square inches per foot of width.

Now referring to slab Table 5-B opposite span of 8'-0" it is seen that for steel area .180 the total safe load is 201 pounds and for steel area of .200 the total safe load is 227 pounds. Interpolating between these values for the given steel area of .187 a total safe load of 210 pounds is obtained. Deducting from this total load 63 pounds, the weight of the 5" slab, gives a safe applied load of 147 pounds per square foot.

EXAMPLE NO. 4. Required to design a fully continuous cinder-concrete slab reinforced with National Reinforcing Slab to have wood wearing surface on cinder fill, a span of 6'-0", live load of 60 pounds per square foot and partition load of 20 pounds per square foot.

Total load applied to slab other than its own weight therefore is:

Live load	60	lbs. per sq. ft.
Partitions	20	" " " "
1" Wood floor	4	" " " "
2" Cinder fill	10	" " " "
Total applied load	94	" " " "

In utilizing the tables for cinder-concrete, selection of values must be restricted to those shown at left of heavy vertical lines. Proceeding with Table 1-B it is seen that the maximum load shown at left of heavy line opposite 6'-0" span is inadequate for the given applied load of 94 pounds. Likewise Table 2-B shows a $3\frac{1}{2}$" slab to be also inadequate.

In Table 3-B however it is seen that a 4" slab is adequate since the maximum total load opposite 6'-0" span is 137 pounds which, after deducting 36 pounds as the weight of a 4" cinder-concrete slab, represents a net applied load of 101 pounds or more than the required 94 pounds.

Using a 4" slab therefore the total load of the problem would become 94 plus 36 or 130 pounds including the weight of the slab. Interpolating for this load between the steel areas of .060 and .080 we obtain a required area of steel of .076 square inches per foot of width. Referring to table of Standard Styles, page 27, it is seen that National Reinforcing, Style BH711 has a sectional area in longitudinal wires of .074 which for all practical purposes meets the requirements.

The resulting design therefore is a 4" cinder concrete slab reinforced with National Reinforcing, Style BH711.
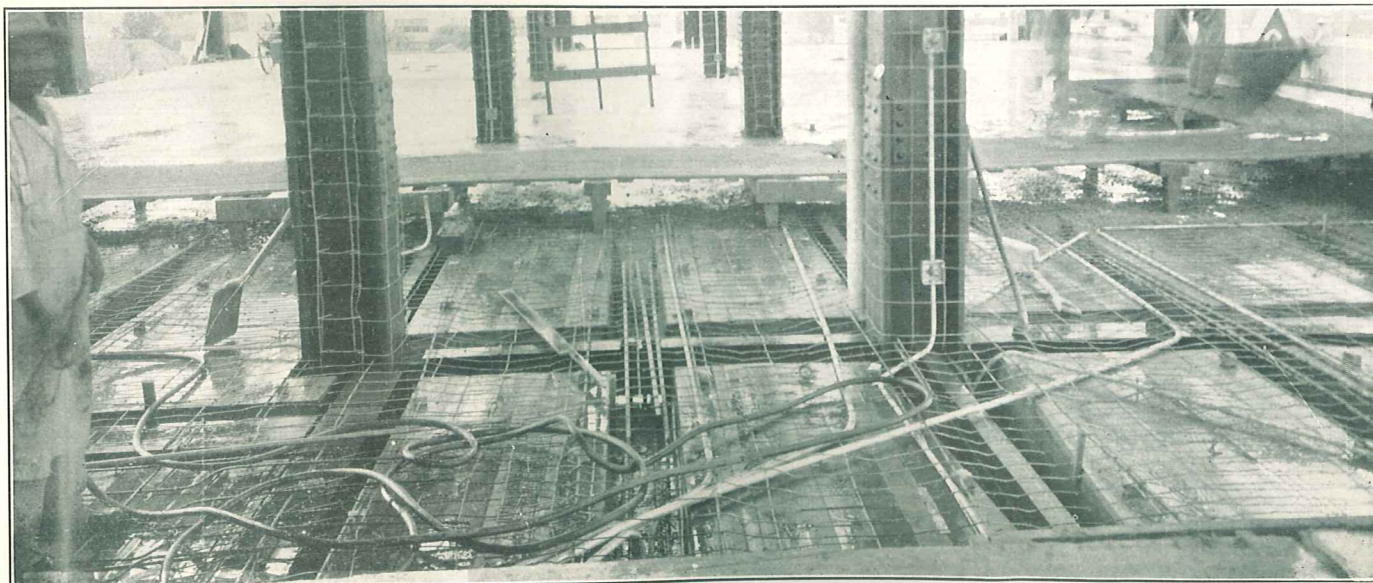
COTTON EXCHANGE, HOUSTON, TEXAS. NATIONAL REINFORCING STYLE BF-710 USED IN ALL FLOORS

TABLE 1-B—3″ SLAB

Maximum Stress in Concrete, 650 Pounds per Square Inch
Weight of Slab, 38 Pounds per Square Foot. Steel ¾″ Above Bottom of Slab
Total Safe Load Uniformly Distributed, in Pounds per Square Foot, Including Weight of Slab

Span of Slab	Maximum Stress in Steel, 20,000 lbs. per square inch													
	Cross Sectional Area Steel Reinforcement, Square Inches per Foot of Width and Recommended "Style" of National Reinforcing													
	Area: .040 Style: BF-1012	Area: .060 Style: BF-812	Area: .080 Style: BH-610	Area: .100 Style: BH-510	Area: .120 Style: B-H49	Area: .140 Style: BH-38	Area: .144 Style: AH-711	Area: .160 Style: TH-49	Area: .180 Style: TH-38	Area: .200 Style: AH-510	Area: .250 Style: TH-17	Area: .300 Style: TH-06		
3′-0″	189	275	369	452	545	625	640	664	693	716	771	815		
3′-6″	139	202	271	332	401	459	470	488	509	526	566	599		
4′-0″	107	155	208	254	308	352	360	374	390	403	434	458		
4′-6″	84	122	164	201	242	278	285	295	308	318	343	362		
5′-0″	68	99	133	163	196	225	230	239	250	258	277	293		
5′-6″		82	110	134	162	186	190	198	206	213	229	242		
6′-0″		69	92	113	136	156	160	166	173	179	193	204		
6′-6″		59	79	96	116	133	136	141	148	153	164	174		
7′-0″			68	83	100	115	118	122	127	132	142	150		
7′-6″			59	72	87	100	102	106	111	115	123	130		

TABLE 2-B—3½″ SLAB

Maximum Stress in Concrete, 650 Pounds per Square Inch
Weight of Slab, 44 Pounds per Square Foot. Steel ¾″ Above Bottom of Slab
Total Safe Load Uniformly Distributed, in Pounds per Square Foot, Including Weight of Slab

Span of Slab	Maximum Stress in Steel, 20,000 lbs. per square inch													
	Cross Sectional Area Steel Reinforcement, Square Inches per Foot of Width and Recommended "Style" of National Reinforcing													
	Area: .040 Style: BF-1012	Area: .060 Style: BF-812	Area: .080 Style: BH-610	Area: .100 Style: BH-510	Area: .120 Style: BH-49	Area: .140 Style: BH-33	Area: .160 Style: TH-49	Area: .176 Style: AH-610	Area: .180 Style: TH-38	Area: .200 Style: AH-510	Area: .250 Style: TH-17	Area: .300 Style: TH-06	Area: .350 Style: TH-005	
4′-0″	128	190	251	311	371	429	488	539	545	564	608	644	675	
4′-6″	101	150	198	246	293	339	385	425	430	446	480	508	533	
5′-0″	82	121	160	199	237	275	312	345	348	361	390	412	432	
5′-6″	68	100	132	165	196	227	258	285	288	298	321	340	357	
6′-0″		84	111	138	165	191	217	239	242	251	270	286	300	
6′-6″		72	95	118	140	162	185	204	206	214	230	244	256	
7′-0″		62	82	102	121	140	159	176	178	184	198	210	220	
7′-6″			71	89	105	122	139	153	155	160	173	183	192	
8′-0″			63	78	93	107	122	135	136	141	152	161	169	
8′-6″				69	82	95	108	119	121	125	135	143	149	

TABLE 3-B—4″ SLAB

Maximum Stress in Concrete, 650 Pounds per Square Inch
Weight of Slab, 50 Pounds per Square Foot.   Steel ¾″ Above Bottom of Slab
Total Safe Load Uniformly Distributed, in Pounds per Square Foot, Including Weight of Slab

Span of Slab	Maximum Stress in Steel, 20,000 lbs. per square inch													
	Cross Sectional Area Steel Reinforcement, Square Inches per Foot of Width and Recommended "Style" of National Reinforcing													
	Area: .040 Style: BF-1012	Area: .060 Style: BF-812	Area: .080 Style: BH-610	Area: .100 Style: BH-510	Area: .120 Style: BH-49	Area: .140 Style: BH-38	Area: .160 Style: TH-49	Area: .180 Style: TH-38	Area: .200 Style: AH-510	Area: .208 Style: TH-28	Area: .250 Style: TH-17	Area: .300 Style: TH-06	Area: .350 Style: TH-005	Area: .400 ....
5′-0″	96	143	197	242	287	331	375	419	461	481	513	545	573	598
5′-6″	79	118	163	200	237	274	310	346	381	397	424	451	474	494
6′-0″		99	137	168	199	230	260	291	320	334	356	379	398	415
6′-6″		84	117	143	170	196	222	248	273	285	303	323	339	354
7′-0″		73	101	124	146	169	191	214	235	245	262	278	292	305
7′-6″			88	108	127	147	167	186	205	214	228	242	255	266
8′-0″			77	95	112	129	146	164	180	188	200	213	224	234
8′-6″				84	99	115	130	145	160	166	177	189	198	207
9′-0″				75	88	102	116	129	142	148	158	168	177	185
9′-6″					79	92	104	116	128	133	142	151	159	166
10′-0″					72	83	94	105	115	120	128	136	143	150

TABLE 4-B—4½″ SLAB

Maximum Stress in Concrete, 650 Pounds per Square Inch
Weight of Slab, 56 Pounds per Square Foot.   Steel ¾″ Above Bottom of Slab
Total Safe Load Uniformly Distributed, in Pounds per Square Foot, Including Weight of Slab

Span of Slab	Maximum Stress in Steel, 20,000 lbs. per square inch													
	Cross Sectional Area Steel Reinforcement, Square Inches per Foot of Width and Recommended "Style" of National Reinforcing													
	Area: .040 Style: BF-1012	Area: .060 Style: BF-812	Area: .080 Style: BH-610	Area: .100 Style: BH-510	Area: .120 Style: BH-49	Area: .140 Style: BH-38	Area: .160 Style: TH-49	Area: .180 Style: TH-38	Area: .200 Style: AH-510	Area: .240 Style: AH-49	Area: .250 Style: TH-17	Area: .300 Style: TH-06	Area: .350 Style: TH-005	Area: .400 ....
5′-0″	115	165	226	275	335	382	441	487	534	640	648	693	729	761
5′-6″	95	136	187	227	276	315	364	403	441	529	535	573	603	629
6′-0″	80	115	157	191	232	265	306	338	371	445	450	481	506	528
6′-6″		98	134	162	198	226	261	288	316	379	383	410	431	450
7′-0″		84	115	140	171	195	225	249	272	327	330	354	372	388
7′-6″		73	100	122	149	170	196	217	237	285	288	308	324	338
8′-0″			88	107	131	149	172	190	209	250	253	271	285	297
8′-6″			78	95	116	132	152	169	185	222	224	240	252	263
9′-0″				85	103	118	136	150	165	198	200	214	225	235
10′-0″					84	95	110	122	133	160	162	173	182	190
11′-0″						79	91	101	110	132	134	143	151	157

TABLE 5-B—5″ SLAB

Maximum Stress in Concrete, 650 Pounds per Square Inch
Weight of Slab, 63 Pounds per Square Foot.   Steel 1″ Above Bottom of Slab
Total Safe Load Uniformly Distributed, in Pounds per Square Foot, Including Weight of Slab

| Span of Slab | Maximum Stress in Steel, 20,000 lbs. per square inch | | | | | | | | | | | | | |
| | Cross Sectional Area Steel Reinforcement, Square Inches per Foot of Width and Recommended "Style" of National Reinforcing | | | | | | | | | | | | | |
	Area: .060 Style: BF-812	Area: .080 Style: BH-610	Area: .100 Style: BH-510	Area: .120 Style: BH-49	Area: .140 Style: BH-38	Area: .160 Style: TH-49	Area: .180 Style: TH-38	Area: .200 Style: AH-510	Area: .250 Style: TH-17	Area: .256 Style: TH-17	Area: .300 Style: TH-06	Area: .350 Style: TH-005	Area: .400	Area: .450
5′-0″	181	244	299	353	408	461	515	581	712	729	768	812	847	880
5′-6″	150	202	247	292	337	381	426	480	589	602	635	671	700	728
6′-0″	126	169	207	245	283	320	358	404	495	506	534	564	588	612
6′-6″	107	144	177	209	241	273	305	344	422	431	455	480	501	521
7′-0″	92	124	152	180	208	235	263	297	363	372	392	414	432	449
7′-6″		108	133	157	181	205	229	258	317	324	342	361	376	391
8′-0″		95	117	138	159	180	201	227	278	285	300	317	331	344
9′-0″			92	109	126	142	159	180	220	225	237	251	261	272
10′-0″				88	102	115	129	145	178	182	192	203	212	220
11′-0″					84	95	106	120	147	151	159	168	175	182
12′-0″							89	101	124	126	133	141	147	153

TABLE 5½-B—5½″ SLAB

Maximum Stress in Concrete, 650 Pounds per Square Inch
Weight of Slab, 69 Pounds per Square Foot.   Steel 1″ Above Bottom of Slab
Total Safe Load Uniformly Distributed, in Pounds per Square Foot, Including Weight of Slab

| Span of Slab | Maximum Stress in Steel, 20,000 lbs. per square inch | | | | | | | | | | | | | |
| | Cross Sectional Area Steel Reinforcement, Square Inches per Foot of Width and Recommended "Style" of National Reinforcing | | | | | | | | | | | | | |
	Area: .060 Style: BF-812	Area: .080 Style: BH-610	Area: .100 Style: BH-510	Area: .120 Style: BH-49	Area: .140 Style: BH-38	Area: .160 Style: TH-49	Area: .180 Style: TH-38	Area: .200 Style: AH-510	Area: .250 Style: TH-17	Area: .288 Style: TH-06	Area: .300 Style: TH-06	Area: .350 Style: TH-005	Area: .400	Area: .450
5′-0″	202	269	335	399	463	527	590	653	808	924	936	987		
5′-6″	167	222	277	330	383	436	487	540	668	765	775	815	855	887
6′-0″	140	187	232	277	322	366	409	453	561	641	650	685	717	745
6′-6″	120	158	198	236	274	312	349	386	478	546	554	584	611	635
7′-0″	103	137	171	204	236	269	301	333	412	471	478	504	527	548
8′-0″		105	131	156	181	206	230	255	315	361	366	386	403	419
9′-0″			103	123	143	163	182	201	249	285	290	305	319	331
10′-0″				100	116	132	147	163	202	231	234	247	258	268
11′-0″					91	109	122	135	167	191	193	204	213	222
12′-0″						92	102	113	140	160	162	171	179	186
13′-0″								97	120	137	139	146	153	159

TABLE 6-B—6″ SLAB

Maximum Stress in Concrete, 650 Pounds per Square Inch
Weight of Slab, 75 Pounds per Square Foot.   Steel 1″ Above Bottom of Slab
Total Safe Load Uniformly Distributed, in Pounds per Square Foot, Including Weight of Slab

Span of Slab	Maximum Stress in Steel, 20,000 lbs. per square inch														
	Cross Sectional Area Steel Reinforcement, Square Inches per Foot of Width and Recommended "Style" of National Reinforcing														
	Area: .080 Style: BH-610	Area: .100 Style: BH-510	Area: .120 Style: BH-49	Area: .140 Style: BH-38	Area: .160 Style: TH-49	Area: .180 Style: TH-38	Area: .200 Style: AH-510	Area: .250 Style: TH-17	Area: .300 Style: TH-06	Area: .320 Style: TH-005	Area: .350 Style: TH-005	Area: .400	Area: .450	Area: .500	Area: .550 ....
5′-0″	293	381	445	510	595	658	721	908							
6′-0″	204	264	309	354	413	457	501	631	745	**791**	815	856	889	919	949
7′-0″	150	194	227	260	303	336	368	463	547	**581**	599	629	653	675	697
8′-0″	115	149	174	199	232	257	282	355	419	**445**	458	482	500	517	534
9′-0″		117	137	157	184	203	223	280	331	**351**	362	380	395	408	422
10′-0″			111	128	149	165	180	227	268	**285**	293	308	320	331	342
11′-0″				105	123	136	149	188	222	**235**	242	255	264	273	282
12′-0″					103	114	125	158	186	**198**	204	214	222	230	237
13′-0″						97	107	134	159	**168**	174	182	189	196	202
14′-0″								116	137	**145**	150	157	163	169	174
15′-0″								101	119	**126**	130	137	142	147	152

TABLE 6½-B—6½″ SLAB

Maximum Stress in Concrete, 650 Pounds per Square Inch
Weight of Slab, 81 Pounds per Square Foot.   Steel 1″ Above Bottom of Slab
Total Safe Load Uniformly Distributed, in Pounds per Square Foot, Including Weight of Slab

Span of Slab	Maximum Stress in Steel, 20,000 lbs. per square inch													
	Cross Sectional Area Steel Reinforcement, Square Inches per Foot of Width and Recommended "Style" of National Reinforcing													
	Area: .080 Style: BH-610	Area: .100 Style: BH-510	Area: .120 Style: BH-49	Area: .140 Style: BH-38	Area: .160 Style: TH-49	Area: .180 Style: TH-38	Area: .200 Style: AH-510	Area: .250 Style: TH-17	Area: .300 Style: TH-06	Area: .350 Style: TH-005	Area: .352 Style: TH-005	Area: .400	Area: .450	Area: .500 ....
5′-0″	332	413	492	570	650	727	805	996						
6′-0″	230	286	342	396	451	505	558	692	823	953	**957**			
7′-0″	169	211	251	291	332	372	411	508	605	700	**704**	735	765	794
8′-0″	130	161	192	223	254	284	314	389	463	535	**538**	563	586	606
9′-0″	102	127	152	176	201	224	248	308	366	423	**425**	444	463	479
10′-0″		103	123	143	162	182	201	249	296	343	**345**	360	375	388
11′-0″			102	118	134	150	166	206	245	283	**285**	298	310	321
12′-0″					113	126	139	173	206	238	**240**	250	260	269
13′-0″						108	119	148	175	203	**204**	213	222	230
14′-0″							103	127	151	175	**176**	184	191	198
15′-0″								110	132	152	**153**	160	167	172

Special Requirements of New York City Building Code

FOR STONE AND CINDER CONCRETE FLOOR SLABS

CONCRETE floor slabs not exceeding 8'-0" span are regulated by the New York City Building Code in accordance with an empirical method of computation for determining their allowable capacities. The special requirements covering this particular type of construction are illustrated by the following excerpts from Article 17 of the New York City Building Ordinance:

"When concrete is used as floor filling it shall consist of one part of Portland cement, and not more than two parts of sand and five parts of stone, gravel or cinders, reinforced, in the case of slab construction, with steel as herein provided. The stone or gravel shall be as required for reinforced concrete in Article 16 of this chapter. Cinders shall be clean, well-burned, steam-boiler cinders.

"When reinforcement is required it shall consist of steel rods or other suitable shapes, of steel fabric. The tensional reinforcement in any case shall be not less than twelve-hundredths per cent in the case of cold drawn steel fabric, nor less than twenty-five-hundredths per cent in the case of other forms, the percentage being based on the sectional area of slab above the center of the reinforcement. The center of the reinforcement shall be at least 1 inch above the bottom of the slab, but in no case shall any part of the reinforcement come within five-eighths of an inch from the bottom of the slab.

"When the concrete floor filling is in the form of slabs the thickness shall be not less than 4 inches, except as otherwise provided in this article for special roof construction.

"In determining the safe-carrying capacities of concrete slab floor fillings, the gross load in pounds per square foot of floor surface shall not exceed the product of the depth in inches of the reinforcement below the top of the slab, by the cross-sectional area in square inches per foot of width of the tensional steel, divided by the square of the span in feet, all multiplied by the following coefficients when cinder concrete is used: 14,000 if the reinforcement is not continuous over the supports, 18,000 if the reinforcement consists of rods or other shapes securely hooked over or attached to the supports, and 26,000 if the reinforcement consists of steel fabric continuous over the supports, and, when stone concrete is used, 16,000, 20,000 and 30,000 respectively."

The carrying capacities of slabs in accordance with these requirements may be reduced to the following formulas if continuous wire fabric is used for the reinforcement:

Let

A^s = Cross sectional area in square inches per foot of width of tensional steel.

d = Depth in inches of the reinforcement below top of slab.

l = Span in feet.

w = Gross load in pounds per square foot of floor surface.

Then with Wire Fabric Reinforcement

$$A^s = \frac{wl^2}{26000d} \text{ (With Cinder-Concrete)}$$

$$A^s = \frac{wl^2}{30000d} \text{ (With Stone-Concrete)}$$

SLAB TABLE FOR SPECIAL NEW YORK CITY REQUIREMENTS

Values Computed in Accordance with Empirical Formulas Required by New York City Building Code for Spans not Exceeding 8' 0"

Sectional Area Wire Reinforcement—Square Inch per Foot Width

Kind of Concrete	Live Load Lbs. per Sq. Ft.	Weight Slab Lbs. per Sq. Ft.	Total Load Lbs. per Sq. Ft.	Thickness of Slab	4' 0"	4' 6"	5' 0"	5' 6"	6' 0"	6' 6"	7' 0"	7' 6"	8' 0"
Cinder	50	36	86	4"	.043	.043	.043	.043	.043	.047	.054	.062	.071
"	75	36	111	4"	.043	.043	.043	.043	.051	.060	.070	.080	.091
"	100	36	136	4"	.043	.043	.044	.053	.063	.074	.086	.098	.112
"	125	36	161	4"	.043	.043	.052	.063	.074	.087	.101	.116	.132
"	150	36	186	4"	.043	.048	.060	.072	.086	.101	.117	.134	.153
"	175	36	211	4"	.043	.055	.068	.082	.097	.114	.133	.152	.173
"	200	36	236	4"	.048	.061	.076	.092	.109	.128	.148	.170	.194
"	225	36	261	4"	.054	.068	.084	.101	.121	.141	.164	.188	.214
"	250	36	286	4"	.059	.074	.092	.111	.132	.155	.180	.206	.235
"	275	36	311	4"	.064	.081	.100	.121	.144	.169	.195	.224	.255
"	300	36	336	4"	.069	.087	.108	.130	.155	.182	.211	.242	.276
Stone	50	50	100	4"	.043	.043	.043	043	043	.047	.055	.063	.071
"	75	50	125	4"	.043	.043	.043	.043	.050	.059	.068	.078	.089
"	100	50	150	4"	.043	.043	.043	.050	.060	.071	.082	.094	.107
"	125	50	175	4"	.043	.043	.049	.059	.070	.082	.095	.109	.124
"	150	50	200	4"	.043	.045	.056	.067	.080	.094	.109	.125	.142
"	175	50	225	4"	.043	.051	.063	.076	.090	.106	.123	.141	.160
"	200	50	250	4"	.045	.056	.070	.084	.100	.117	.136	.156	.178
"	225	50	275	4"	.049	.062	.076	.092	.110	.129	.150	.172	.196
"	250	50	300	4"	.053	.068	.083	.101	.120	.141	.164	.188	.213
"	275	50	325	4"	.058	.073	.090	.109	.130	.153	.177	.203	.231
"	300	50	350	4"	.062	.079	.097	.118	.140	.164	.191	.219	.249

For sizes, weights, and sectional areas of National Reinforcing see page 27.

National Reinforcing
for
Slab Reinforcement

GENERAL DESCRIPTION

NATIONAL REINFORCING is an electrically welded wire fabric furnished in various gauges and spacings of wires. The material is fabricated by automatic machines which accurately space and securely assemble the wires into fabric form by electrically welding each longitudinal and transverse member at their intersection. The fabric is manufactured from a special high-grade cold drawn steel wire, which may be furnished with either plain or galvanized finish. The wire of which the fabric is made has high tensile strength, together with elastic and ductile properties of such a character as to render it especially suitable for the reinforcement of concrete.
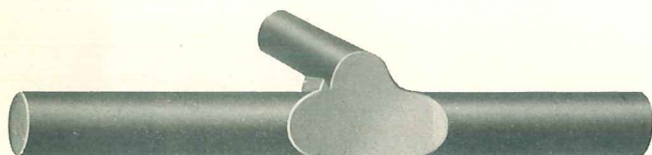

Fig. 9. Cross-section of Weld, which Photographically Illustrates the "Fusing" Together of Longitudinal and Transverse Members

National Reinforcing is distinguished from other types of WOVEN or TWISTED fabrics in that the longitudinal and transverse members are not connected by any form of wraps, clips, or ties. In National Reinforcing, rigidity of the mesh is obtained by welding, or more properly by actually fusing together the transverse and longitudinal members at every point of intersection, by means of electricity. The result is an absolutely rigid connection at every joint; in fact, a joint of such strength that the force necessary to strip a transverse member apart from the longitudinal to which it is welded actually exceeds, in the greater majority of cases, the tensile strength of the longitudinal member itself—see Fig. 9. Furthermore, this is accomplished without any loss in tensile strength of the fabric either longitudinally or transversely; a phenomenon readily accounted for by the fact that the process of electric welding does not merely "braze" the wires together but actually FUSES the metal of the two intersecting wires into one homogeneous section. This fact has been repeatedly substantiated by the most exhaustive laboratory investigations wherein tensile tests upon individual wires taken from the finished fabric invariably prove the weld to be the strongest part of the wire.

STRUCTURAL ADVANTAGES

In National Reinforcing, the rigidity of the welded connections maintains a fixed relationship between the longitudinal and transverse members, and prevents any distortion of the fabric regardless of the shape or size of the sheet into which the material may be cut. Furthermore the longitudinal and transverse members cross at right angles, thus forming a square or rectangular mesh without any diagonal or inter-woven member to obstruct the coarse aggregate of the concrete, or which might loosen and slip out or unravel when the fabric is cut into sheets.

National Reinforcing, having no wraps, ties, or clips where the members are joined, permits the concrete to flow freely around all parts of the reinforcement and completely cover every wire. This results not only in a perfect bond or union between the concrete and its reinforcement, but assures a concrete free from pockets or voids and consequently having maximum density. With National Reinforcing the bond is doubly effective since the material provides not only a bond of adhesion between the concrete and the surface of the wires themselves, but also a mechanical bond due to the rigidly connected cross members which affords a definite anchorage against slipping in the concrete, a "dead man" effect.

National Reinforcing usually comes to the work in rolls which, in some sizes, may contain as much as 1500 square feet. This enables convenient handling and storage of the material, while the length of a roll is such that large areas may be quickly and economically covered. This provides unbroken continuity of the reinforcement usually extending across the entire width of the building. Full effectiveness of reinforcement is thus obtained at every section of the slab while the almost complete absence of laps and splices reduces the required quantity of steel to the absolute minimum.

The distinctive structural advantages of National Reinforcing, which render it the ideal type of slab reinforcement may be briefly summarized as follows:

1—*Cold drawn wire; not hot rolled bars.*

2—*High tensile strength combined with proper ductile properties.*

3—*Large sheets or rolls; not loose individual members.*

4—*Spacing of members accurately fixed by machinery at factory.*

5—*Rigid welded connections; no clips, twists, wraps, or ties.*

6—*Square or rectangular mesh; no zigzag criscross members to obstruct flow of concrete.*

7—*Every pound efficient reinforcement; no "idle" or non-effective material at intersections.*

8—*Mechanical bond with concrete due to rigidly connected cross members.*

9—*Unbroken continuity of reinforcement; usually across entire width of building.*

10—*Ease and accuracy of installation.*

11—*Convenient handling and storage.*

12—*Cannot become easily mutilated in shipment.*

13—*Either plain or galvanized finished.*

14—*Wide range of sizes both in gauge and spacing.*

HOW TO SPECIFY

Welded wire fabric is no longer considered as merely "steel reinforcement." Its outstanding characteristics, indicated not only by the quality and physical properties of the wire itself but also by certain definite structural advantages resulting from its method of fabrication, have led to a distinct classification of the material as distinguished from bar reinforcement. This is evidenced by the prevalence of specifications calling definitely for "welded wire fabric" and also recognition of the material by the building codes of several leading cities wherein wire is given a separate classification and assigned a higher allowable designing stress than bars.

As pointed out under "Allowable Stresses," page 18, cold drawn wire has certain distinguishing characteristics, as compared with hot rolled bars, which offer definite advantages as an efficient and economical reinforcement. Much of the structural merit of wire as a reinforcement, however, is nullified if a hard brittle grade of wire is used. Therefore, care must be exercised in the selection of the wire for reinforcing purposes in order to assure its proper quality. This may be accomplished either by careful specifications accompanied by constant test and analysis, or by selection of a product known to be definitely standardized as to its composition and essential physical properties. In this connection it should be realized that selection of merely "wire mesh" is not a sufficient safeguard in this respect since some of the hard grades of wire can be fabricated into a mesh of the woven or twisted type.

The specification of "welded wire fabric," however, is an absolute protection against high carbon wire by reason of the fact that a hard wire of high carbon content cannot be successfully cross-welded into mesh form. This is not a matter of preference or even integrity on the part of the manufacturer but is simply a manufacturing impossibility. Appreciation of this important peculiarity of welded fabric assures the designer that, by specifying "*welded*" wire fabric, he will, without need

of constant vigilance in the matter of inspection, always obtain a material of proper and uniform composition by reason of the manufacturer's inability to furnish it otherwise.

Specifications of a definite size of National Reinforcing must describe the spacing and gauge for both the longitudinal and transverse members. Thus, National Reinforcing 4" x 16"— 6 and 10, would indicate a fabric in which the longitudinal wires are No. 6 gauge spaced on 4-inch centers welded to transverse wires of No. 10 gauge spaced on 16-inch centers. Another more convenient means of designating this same fabric is by Style Number, as shown in table of Standard Styles, page 27, whereby letters refer to the spacing and numerals indicate the gauge; thus, National Reinforcing Style BH610. The "Style" letters and numerals refer respectively to the spacing of wires and to the gauge of wires; for instance, "BD" means 4" spacing of longitudinal wires and 8" spacing of transverse wires, and "1112" means No. 11 gauge longitudinal wires and No. 12 gauge transverse wires.

RANGE OF MANUFACTURE

Aside from its distinct structural adaptability to slab reinforcement, one of the chief advantages of National Steel Fabric results from the fact that practically any desired size of mesh and wire may be obtained. This feature affords great latitude to the designer in his selection of the reinforcement, thereby enabling him to specify practical and economical Styles which will meet the particular requirements of each individual structure. The standard Styles of fabrics most commonly used are listed on page 27, and it is usually advisable, because of price and to assure prompt delivery, to restrict selection to these sizes although the nearest standard Styles may be slightly heavier than actually required.

In cases where the requirements of the work cannot be reasonably met with a standard Style and the required quantity is sufficient to justify the use of a special fabric, any desired combination of spacing and gauge may be obtained within the limits tabulated below.

RANGE OF MANUFACTURE

Longitudinal Members		Transverse Members	
Spacing	Size	Spacing	Size
2", 3", 4", 6", 8", 9" or 12"	16 gauge to ⅜" Dia. .0625" to .375"	2", 3", 4", 6", 8", 9" 10", 12", 16" or 18"	16 gauge to 15/32" Dia. .0625" to .468"

Furnished in plain or galvanized finish, in Rolls or Sheets of any desired length, and in widths from 24 inches to 138 inches

NATIONAL REINFORCING STANDARD STYLES

Dimensions, Areas and Weights

Suitable Uses	Style	Spacing Long.	Spacing Tran.	Gauge of Wire Long.	Gauge of Wire Tran.	Sec. Area Sq. In. per Lin. Ft. Long.	Sec. Area Sq. In. per Lin. Ft. Tran.	Weight per 100 Sq. Ft.
Gunite, Composition Flooring, Fireproofing, Etc.	AA 1414	2"	2"	14	14	.030	.030	21
	AA 1212	2"	2"	12	12	.052	.052	37
	TT 1414	3"	3"	14	14	.020	.020	14
	TT 1212	3"	3"	12	12	.035	.035	25
	TT 1010	3"	3"	10	10	.057	.057	41
	BB 1414	4"	4"	14	14	.015	.015	11
	BB 1313	4"	4"	13	13	.020	.020	14
	BB 1212	4"	4"	12	12	.026	.026	19
	BB 1010	4"	4"	10	10	.043	.043	31
Gunite, Canal Lining, Etc.	BB 88	4"	4"	8	8	.062	.062	44
	BB 66	4"	4"	6	6	.087	.087	62
	BB 44	4"	4"	4	4	.120	.120	85
Sidewalks, Temperature Reinforcing, Ground Floors, Etc.	CC 1212	6"	6"	12	12	.017	.017	13
	CC 1010	6"	6"	10	10	.029	.029	21
	CC 99	6"	6"	9	9	.035	.035	25
	CC 88	6"	6"	8	8	.041	.041	30
	CC 77	6"	6"	7	7	.049	.049	36
	CC 66	6"	6"	6	6	.058	.058	42
Slab Reinforcing, Etc. (One direction only)	AH 711	2"	16"	7	11	.148	.008	55
	AH 610	2"	16"	6	10	.174	.011	65
	AH 510	2"	16"	5	10	.202	.011	75
	AH 49	2"	16"	4	9	.239	.013	89
	AH 38	2"	16"	3	8	.280	.015	104
	TH 711	3"	16"	7	11	.098	.009	38
	TH 610	3"	16"	6	10	.116	.011	45
	TH 510	3"	16"	5	10	.135	.011	52
	TH 49	3"	16"	4	9	.160	.013	61
	TH 38	3"	16"	3	8	.187	.015	72
	TH 28	3"	16"	2	8	.217	.015	83
	TH 17	3"	16"	1	7	.252	.018	96
	TH 06	3"	16"	0	6	.295	.022	113
	BH 711	4"	16"	7	11	.074	.008	30
	BH 610	4"	16"	6	10	.087	.011	35
	BH 510	4"	16"	5	10	.101	.011	40
	BH 49	4"	16"	4	9	.120	.013	48
	BH 38	4"	16"	3	8	.140	.015	56
	BH 28	4"	16"	2	8	.162	.015	64
Beam Wrapping, Fireproofing, Etc.	BD 1313	4"	8"	13	13	.020	.010	11
	BD 1214	4"	8"	12	14	.026	.008	12
	BD 1212	4"	8"	12	12	.026	.013	14
	BD 1112	4"	8"	11	12	.034	.013	17
	BD 1012	4"	8"	10	12	.043	.013	20
Concrete Pipe, Etc.	BD 912	4"	8"	9	12	.052	.013	23
	BD 812	4"	8"	8	12	.062	.013	27
	BD 711	4"	8"	7	11	.074	.017	33
Slab Reinforcing, Driveways, Etc.	BF 1012	4"	12"	10	12	.043	.009	19
	BF 912	4"	12"	9	12	.052	.009	22
	BF 812	4"	12"	8	12	.062	.009	26
	BF 711	4"	12"	7	11	.074	.011	31
	BF 610	4"	12"	6	10	.087	.014	37
	BF 510	4"	12"	5	10	.101	.014	42
	BF 49	4"	12"	4	9	.120	.017	50

TABLES FOR COMPUTING WEIGHT OF NATIONAL REINFORCING STYLES

Weight in Pounds per 100 Sq. Ft. of Longitudinal Wires

Gauge of Wires	Pounds per Foot	2"	3"	4"	5"	6"	10"	12"
6-0	.5681	352.22	238.60	181.79	147.71	124.98	79.53	68.17
5-0	.4943	306.47	207.61	158.18	128.52	108.75	69.20	59.32
4-0	.4136	256.43	173.71	132.35	107.54	90.99	57.90	49.63
3-0	.3505	217.31	147.21	112.16	91.13	77.11	49.07	42.06
2-0	.2922	181.16	122.72	93.50	75.97	64.28	40.91	35.06
0	.2506	155.37	105.25	80.19	65.16	55.13	35.08	30.07
1	.2136	132.43	89.71	68.35	55.54	46.99	29.90	25.63
2	.1838	113.96	77.20	58.82	47.79	40.44	25.73	22.06
3	.1584	98.21	66.53	50.69	41.18	34.85	22.18	19.01
4	.1354	83.95	56.87	43.33	35.20	29.79	18.96	16.25
5	.1143	70.87	48.01	36.58	29.72	25.15	16.00	13.72
6	.09832	60.96	41.29	31.46	25.56	21.63	13.76	11.80
7	.08356	51.81	35.10	26.74	21.73	18.38	11.70	10.03
8	.07000	43.40	29.40	22.40	18.20	15.40	9.80	8.40
9	.05866	36.37	24.64	18.77	15.25	12.91	8.21	7.04
10	.04861	30.14	20.42	15.56	12.64	10.69	6.81	5.83
11	.03873	24.01	16.27	12.39	10.07	8.52	5.42	4.65
12	.02969	18.41	12.47	9.50	7.72	6.53	4.16	3.56
13	.02233	13.84	9.38	7.15	5.81	4.91	3.13	2.68
14	.01707	10.58	7.17	5.46	4.44	3.76	2.39	2.05
15	.01385	8.58	5.80	4.43	3.60	3.04	1.94	1.66
16	.01043	6.48	4.38	3.34	2.72	2.30	1.46	1.25

Weight in Pounds per 100 Sq. Ft. of Transverse Wires

Gauge of Wires	Pounds per Foot	2"	3"	4"	6"	8"	12"	16"
0	.2506	155.37	103.58	77.69	51.79	38.84	25.89	19.42
1	.2136	132.43	88.29	66.22	44.14	33.11	22.07	16.55
2	.1838	113.96	75.97	56.98	37.98	28.49	18.99	14.24
3	.1584	98.21	65.47	49.10	32.74	24.55	16.37	12.28
4	.1354	83.95	55.97	41.97	27.98	20.99	13.99	10.49
5	.1143	70.87	47.24	35.43	23.61	17.72	11.81	8.86
6	.09832	60.96	40.64	30.48	20.32	15.24	10.16	7.62
7	.08356	51.81	34.54	25.90	17.27	12.95	8.63	6.48
8	.07000	43.40	28.93	21.70	14.47	10.85	7.23	5.43
9	.05866	36.37	24.25	18.18	12.12	9.09	6.06	4.55
10	.04861	30.14	20.09	15.07	10.05	7.53	5.02	3.77
11	.03873	24.01	16.01	12.01	8.00	6.00	4.00	3.00
12	.02969	18.41	12.27	9.20	6.13	4.60	3.07	2.30
13	.02233	13.84	9.23	6.92	4.61	3.46	2.31	1.73
14	.01707	10.58	7.06	5.29	3.53	2.65	1.76	1.32
15	.01385	8.58	5.70	4.28	2.86	2.15	1.43	1.08
16	.01043	6.48	4.30	3.24	2.15	1.62	1.08	.81

EXAMPLE: Weight per 100 square feet of 6 inches by 12 inches fabric with longitudinal wires No. 0, transverse wires No. 6. Add to weight of longitudinal wire No. 0 spaced 6 inches (55.13 lbs.), the weight of transverse wire No. 6 12 inches (10.16 lbs.) making total of 65.29 lbs. per 100 square feet. Take commercial weight to nearest Pound, or 65 lbs.

TABLE FOR COMPUTING CROSS-SECTIONAL AREA OF NATIONAL REINFORCING STYLES

Area in Square Inches Per Foot of Width for Various Spacing of Wires

Gauge *W & M	Diameter Inches	Area Square Inches	2"	3"	4"	5"	6"	7"	8"	9"	10"	12"	14"	16"	18"
6-0	.4615	.16728	1.004	.669	.502	.402	.335	.287	.251	.223	.201	.167	.143	.125	.112
5-0	.4305	.14556	.874	.582	.437	.349	.291	.250	.218	.194	.175	.146	.125	.109	.097
4-0	.3938	.12180	.731	.487	.365	.292	.244	.209	.183	.162	.146	.122	.104	.091	.081
3-0	.3625	.10321	.619	.413	.310	.248	.206	.177	.155	.138	.124	.103	.088	.077	.069
2-0	.3310	.08605	.516	.344	.258	.207	.172	.148	.129	.115	.103	.086	.074	.065	.067
0	.3065	.07378	.443	.295	.221	.177	.148	.126	.111	.099	.089	.074	.063	.056	.049
1	.2830	.06290	.377	.252	.189	.151	.126	.107	.094	.084	.075	.063	.054	.047	.041
2	.2625	.05411	.325	.217	.162	.130	.108	.093	.081	.072	.065	.054	.047	.041	.036
3	.2437	.04664	.280	.187	.140	.112	.093	.080	.070	.062	.056	.047	.040	.035	.031
4	.2253	.03986	.239	.160	.120	.096	.080	.068	.059	.053	.048	.040	.034	.030	.026
5	.2070	.03365	.202	.135	.101	.081	.067	.058	.050	.045	.040	.034	.029	.025	.022
6	.1920	.02895	.174	.116	.087	.069	.058	.050	.043	.039	.035	.029	.025	.022	.019
7	.1770	.02460	.148	.098	.074	.059	.049	.042	.037	.033	.030	.025	.021	.018	.016
7½	.1695	.02256	.135	.090	.068	.054	.045	.039	.034	.030	.027	.023	.019	.017	.015
8	.1620	.02061	.124	.082	.062	.049	.041	.035	.031	.027	.025	.021	.018	.015	.014
9	.1483	.01727	.104	.069	.052	.041	.035	.029	.026	.023	.021	.017	.015	.013	.011
9½	.1416	.01575	.095	.063	.047	.038	.032	.027	.024	.021	.019	.016	.014	.012	.010
10	.1350	.01431	.086	.057	.043	.034	.029	.025	.021	.019	.017	.014	.012	.011	.009
11	.1205	.01140	.068	.045	.034	.027	.023	.019	.017	.015	.014	.011	.009	.008	.007
11½	.1130	.01002	.060	.040	.030	.024	.020	.017	.015	.013	.012	.010	.009	.008	.007
12	.1055	.00874	.052	.035	.026	.021	.017	.015	.013	.012	.010	.009	.007	.006	.006
12½	.0985	.00762	.046	.030	.023	.018	.015	.013	.011	.010	.009	.007	.007	.006	.005
13	.0915	.00657	.040	.027	.020	.016	.013	.011	.010	.009	.008	.006	.006	.005	.004
14	.0800	.00502	.030	.020	.015	.012	.010	.009	.008	.007	.006	.005	.004	.004	.003
15	.0720	.00401	.024	.016	.012	.010	.008	.007	.006	.005	.005	.004	.004	.003	.003
16	.0625	.00369	.022	.015	.011	.008	.007	.006	.005	.005	.004	.004	.003	.003	.002

* Washburn & Moen

Mill: Monessen, Pa. (Pittsburgh District.)

Originating Railroad: P. & L. E. R. R.

Finish: PLAIN or GALVANIZED as specified (plain fabric will be shipped on all unspecified orders) **Tensile Strength:** Wire used in all fabric will develop 70,000 pounds per square inch.

Widths: (ROLLS or SHEETS). For 4" spacing of longitudinal wires, maximum width is 112" and is measured from center to center of outside longitudinal wires. For 3" and 6" spacing of longitudinal wires, maximum width is 60", with 138" possible in some styles and is measured from center to center of outside longitudinal wires. For widths under 40" apply to Pittsburgh office for prices. All transverse wires will have close overhang (½" or less) unless otherwise specified.

Lengths: ROLLS—Stock lengths 100' to 300' depending on style. Customer may specify length of rolls on orders not shipped from stock. SHEETS—No extra for sheets 8' or over. Length of sheets to be specified by customer. For lengths under 8' apply to Pittsburgh office for prices.

Prices: Apply to nearest office.

Note: The "Style" letter and numerals refer respectively to the spacing of wires and to the gauge of wires; for instance, "BD" means 4" spacing of longitudinal wires and 8" spacing of transverse wires, and "1112" means No. 11 gauge longitudinal wires and No. 12 gauge transverse wires.